Politecnico di Torino

Laurea Magistrale in Eco Design

DESIGN AND ANALYSIS OF SUSTAINABLE WAYS FOR WATER PURIFICATION

USING OF RAINWATER HARVESTING AND VORTEX TECHNOLOGIES FOR AFRICAN VILLAGES

Author

Mina Sarafzadeh

Supervisor

Prof. Pier Paolo Peruccio

Co-Supervisor

Prof. Elena Comino

A thesis submitted in fulfillment of the requirements for the degree of Master of Science

December 2022

ABSTRACT

Because of the current situation of global water shortage, finding strategies that can effectively guarantee water safety and sustainable use has become an urgent problem that needs to be solved at present.

source of clean water and access to safe and clean drinking water is a major step forward for the population of arid and semi-arid regions of the world.

According to the research, most deaths due to lack of access to safe water supply occur in areas of the world that even have adequate annual precipitation(tropical climate).

They get sick because they don't have the necessary facilities for water treatment and improper using surface water, the majority of rural areas in these regions are not connected to water supply networks and the costs of exploiting available resources are relatively high. The implications of lack of safe water and access to adequate sanitation are widespread. Young children die from dehydration and malnutrition, results of suffering from diarrheal illnesses that could be prevented by clean water and good hygiene.

This research, therefore, led to the in-depth study of two specific technologies for creating potable water in African villages that people in these areas don't access, based on rainwater harvesting system and vortex technology.

Rainwater harvesting has proven to be an effective and sustainable solution to overcome or reduce water shortages all over the world. Especially in the light of climate change, population growth and increased pressure on natural water resources, rainwater is becoming more and more attractive as an alternative water source.

Vortex technology was first observed by Viktor Schauberger (Austrian scientist 1885-1958), who creates implosion in the water with returns it to its natural being as a life-forming energetic process. After the implosion, water's inner equilibrium is restored:

- Molecules form microclusters;
- Dissolved oxygen levels are elevated and activated;
- Self-cleaning, anti-bacterial .

There is a long list of benefits for drinking and using vortex water.

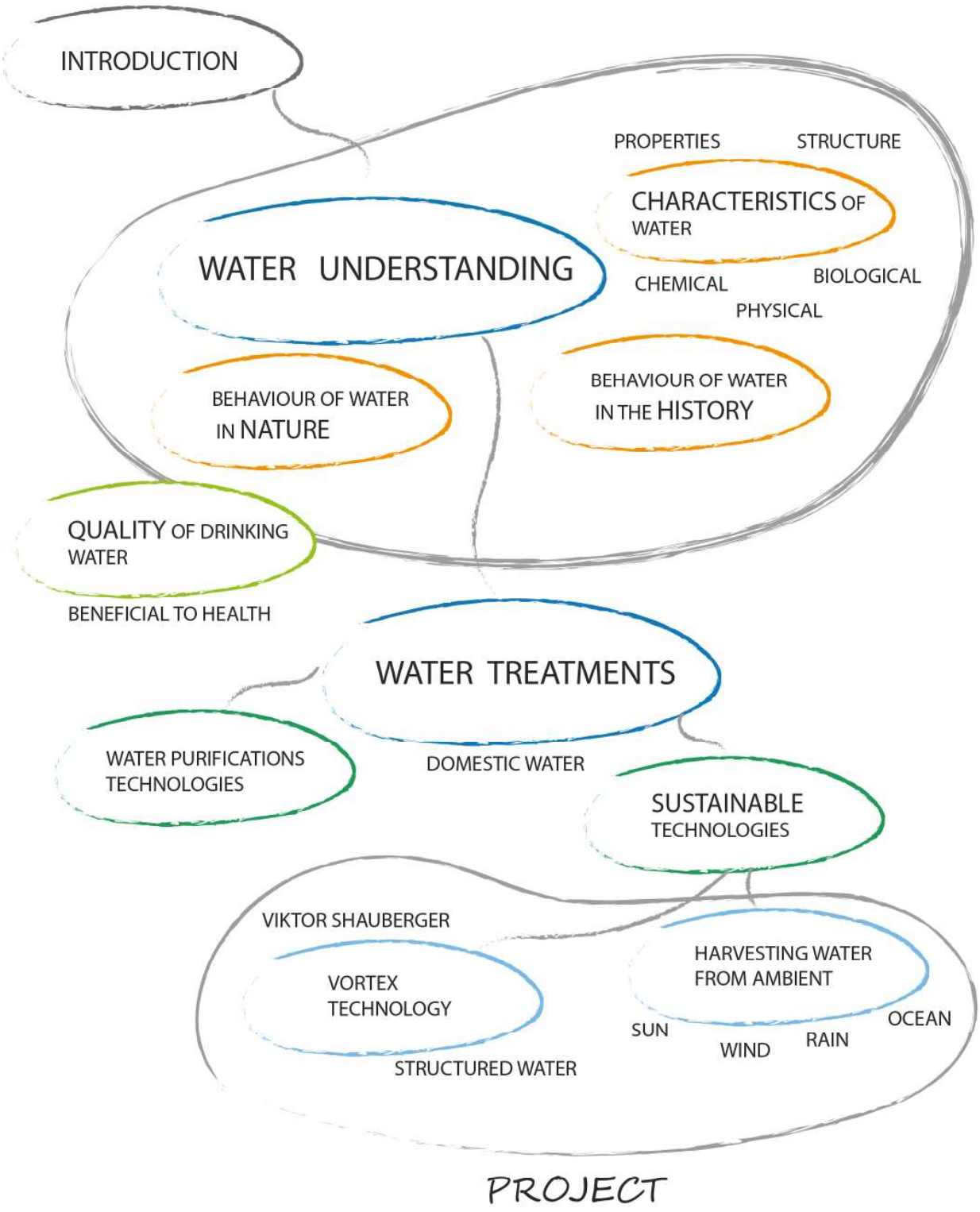
The most innovative aspect of these technologies lies in the fact that the water is able to spontaneously self-purify itself at ambient temperature and pressure, without the use of any filtering system.

In the end of paper I designed an structure for catching rainwater and filter that and this technique allows us to directly use the harvested water for drinking purpose with sustainable filtration ways.

And the major benefit is, it is a roofless technique, so we can catch the rainwater anywhere regardless of the roof.

KEYWORDS:

Safty water
Water treatment
African villages
Rainwater harvesting
vortex tchnology
Viktor Schauberger
Implosion


INTRODUCTION
PROPERTIES
STRUCTURE
CHARACTERISTICS OF WATER
WATER UNDERSTANDING
CHEMICAL
BIOLOGICAL
PHYSICAL
BEHAVIOUR OF WATER IN NATURE
BEHAVIOUR OF WATER IN THE HISTORY
QUALITY OF DRINKING WATER
BENEFICIAL TO HEALTH
WATER TREATMENTS
WATER PURIFICATIONS TECHNOLOGIES
DOMESTIC WATER
SUSTAINABLE TECHNOLOGIES
VIKTOR SHAUBERGER
VORTEX TECHNOLOGY
STRUCTURED WATER
HARVESTING WATER FROM AMBIENT
SUN
WIND
RAIN
OCEAN
PROJECT

INTRODUCTION

According to the prediction of International Water Association, under the business-as-usual scenario, the world is projected to face a 40% global water deficit by 2030. This challenge has promoted the search of new methods for the sustainable use of water.[1]

As more than a billion people on this earth have no access to potable water that is free of pathogens, technologies that are cost effective and suitable for developing countries must be considered. Sustainable operation of these treatment processes taking into consideration locally available materials and ease of maintenance need to be considered.

The main objective of this Research Project is therefore to understand more deeply the properties of water through a holistic approach and to identify the principles and treatment techniques appropriate to enhance its overall qualities.

The research area is the rural areas of Africa, and therefore the management of the water resource Is taken into consideration the overall water cycle that goes from the withdrawal of water from the environment, to the water treatment, distribution and direct use.

The research and experimentation activity used the sustainable techniques of water treatment and finding the best alternative for the rural areas of Africa as the basis of analysis. However, the knowledge gained during the research on the properties of water and alternative water treatments can also be applied in different fields.

In summary, the Research Project has set itself the following objectives:

- Deepen and understand the properties of water considering in particular the scientific theories that define water as an open dynamic system;

- Experiment and verify alternative water treatments;

- Design of a rainwater harvesting construction with filtration and vitalization.

1 M. García-Montoya, A. Bocanegra-Martinez, F. Napoles-Rivera, M. Serna-Gonzalez, J.M. Ponce-Ortega, M.M. El-Halwagi, Simultaneous design of water reusing and rainwater harvesting systems in a residential complex, Comput. Chem. Eng. 76 (2015) 104–116.

INDEX

1 WATER UNDERSTANDING

1. WATER UNDERSTANDING

1.1 WATER FACTS

Next to oxygen, water is the substance we need most and give the least thought to.Plants live on food they make themselves from water, sunlight, carbon dioxide and inorganic minerals. Animals and man are subject to the organic laws of nature.

The human brain is composed of approximately 80% water and needs to be rehydrated or refreshed every 24 hours. Approximately 85% of blood is composed of water that also needs to be refreshed to enliven and vitalize it.The body is able to create a portion of its own distilled water by oxidation of sugars, fats and protein. The body's temperature is controlled through water dynamics.

Approximately 15% to 70% of the total water in our body is stored in muscles, another 10% to 15% in the skin. When we are born, we are about 98% water. When we reach adulthood we are about 70% water. As we age, our bodies harden as we lose the ability to store and use water. Aging is literally a slow process of dehydration. Water covers ¾ of the earth's surface and makes up approximately ¾ of our body weight. Our muscles are composed of ¾ water. The liver is 69% water, and our bones are 22% water. In the same way that water is not evenly distributed in the body, the water of earth is not evenly distributed over its surface[1].

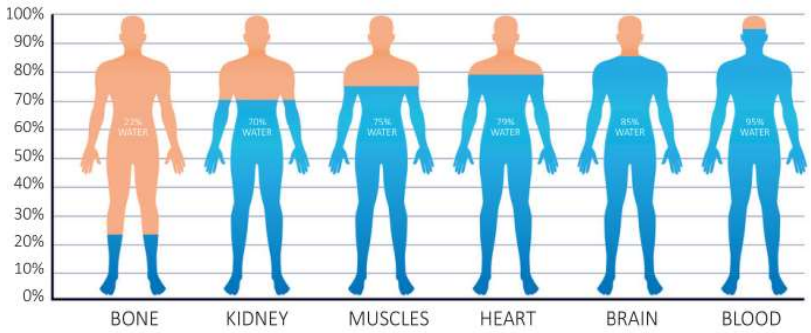


Figure 1: Water Composition of the human body

https://solsarin.com/percentage-of-water-in-human-body-chart/

Water covers 71% of the Earth's surface. Most of the water that is on our planet constitutes oceans and seas (97.5%), while the rest is mainly fresh water of which the majority is stored in the glaciers and in permanent snow (1.72% of total). 0.77% are groundwater and the 0.0075% of the fresh water lakes and rivers[2]. The remaining percentage is given by inland seas, salt lakes, humidity soil and atmospheric water.

1 http://phaelosopher.com/2010/10/31/a-real-life-clinical-trial-opportunity-for-mms/

2 UNESCO, Divisione Scienze dell'Acqua, Paris – France. Basics of Water Resources. Course Book. United Nations Environment Programe – Vital Water Graphics: An Overview of the State of the World's Fresh and Marine Waters, second edition, 2008

here are many different types of water on our earth : rain water, snow water, raw water, boiled water, hard water, soft water, tap water, heavy water, deionized water, filtered water, glacier water, distilled water, stagnant water, and polluted water are just some of them.

We know that the water's basic molecular formula is HOH or H_2O. This formula is true for water only when it is in a vapor form. When water is condensed from vapor into liquid, it becomes a much more complex formula[3].

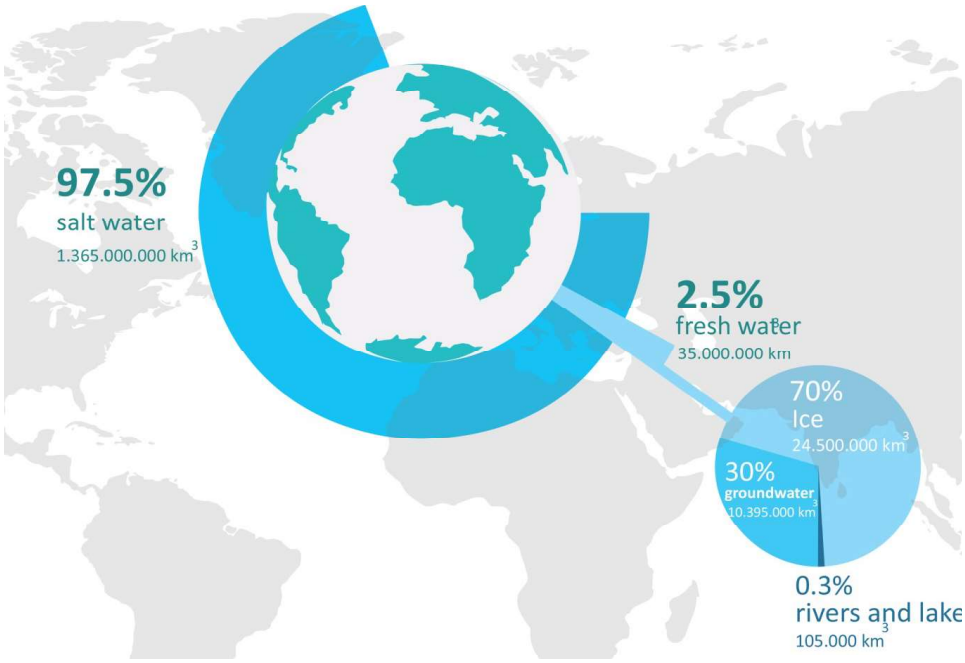


Figure 2: water on our planet

Water is the only material on earth that is simultaneously available in three different states: solid, liquid and gases. In chemistry and physics, these three states of matter are known as phases. The state of each phase is dependent on the temperature of the substance.

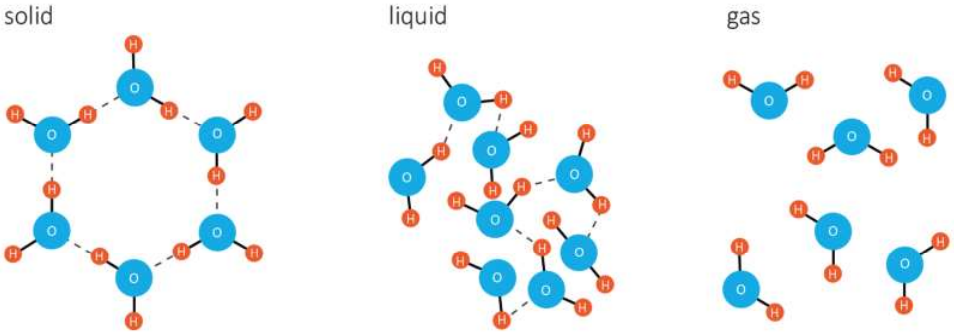


Figure 3: three different states of water

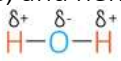
As a solid, when water is cold enough, the movement of the water molecules is so slow that they cannot break their hydrogen bonds at all.

3 John D.Hem, Study and Interpretation of the chemical characteristics of Natural Water, United States goverment printing office, 1985, p.1-4

As a liquid, water molecules are constantly forming and breaking hydrogen bonds with each other. Their constant motion allows them to collide, but then pull away from each other just as quickly!As a gas, when water is hot enough, the movement of the water molecules is so fast that they hardly form hydrogen bonds at all[4].

1.2 PROPERTIES AND STRUCTURE OF WATER

Water is a tiny molecule with the molecular formula H_2O, consisting of two light hydrogen atoms attached to each 16-fold heavier oxygen atom. Each hydrogen atom has a nucleus consisting of a single positively-charged proton surrounded by a 'cloud' of a single negatively-charged electron and the oxygen atom has a nucleus consisting of a eight positively-charged protons and eight un-charged neutrons surrounded by a "cloud" of a eight negatively-charged electrons. On forming the molecule, the ten electrons pair up into five 'orbitals', one pair closely associated with the oxygen atom, two pairs associated with the oxygen atom as 'outer' electrons and two pairs forming each of the two identical O-H covalent bonds.

The eight outer electrons are often shown as the pairs of dots in  where the pairs of electrons between the O and H atoms represent the O-H covalent bonds and the other two pairs of electrons represent the so-called 'lone pairs'. These electron pairs form electron 'clouds' that are spread out around the oxygen nucleus as they repel each other. This is the reason for water's bent structure.The eight positive charges in the oxygen nucleus attract all these electrons strongly relative to the single positive charges on each of the hydrogen atoms. This leaves the hydrogen atoms partially denuded of electrons, and hence partially positively charged, and the oxygen atom partially negatively charged, that is 

Due to the presence of these charges and the bent nature of the molecule, the center of the po itive charge (half way between the two hydrogen atoms) does not coincide with the center of the negative charge (on the oxygen atom). In liquid water, this gives a molecular dipole moment from the center of negative charge to the center of positive charge, equivalent to a unit negative charge (that is, one electron) separated from a unit positive charge by 0.061 nm. The presence of this dipole moment in all water molecules causes its polar nature[5].

Water molecules are tiny and V-shaped with molecular formula H_2O. Water is much smaller than almost all other molecules. For example, it has a smaller volume, and is much lighter than the four other common atmospheric molecules, oxygen (O_2), nitrogen (N_2), argon (Ar) and carbon dioxide (CO_2); the density of water vapor being just 62% the density of dry air[6].

4 http://createtodiscover.com/water/section4.php
5 https://en.wikipedia.org/wiki/Properties_of_water
6 A.Picard, R. S. Davis, M. Gläser and K. Fujii, Revised formula for the density of moist air (CIPM-2007) Metrologia 45(2008), p.149-155

In the liquid state, while 80% of the electrons being concerned with bonding, the three atoms do not stay together as the hydrogen atoms are continually exchanging between water molecules. Both acids and bases catalyze this exchange and even when at its slowest (at pH 7), the average time for the atoms in an H_2O molecule to stay together is only about a millisecond. As this brief period is, however, much longer than the timescales encountered during investigations into water's hydrogen bonding or hydration properties, water is usually treated as a permanent structure[7].

The water molecule consists of two light atoms (H) and a relatively heavy atom (O). The approximately 16-fold difference in mass gives rise to its ease of rotation and the significant relative movements of the hydrogen nuclei, which are in constant and significant relative movement.

The electron density distribution for water with higher density contours around the oxygen atom omitted for clarity. The polarizability of the molecule is almost isotropic, centered around the O-aom with only small polarizabilities centered on the H-atoms.

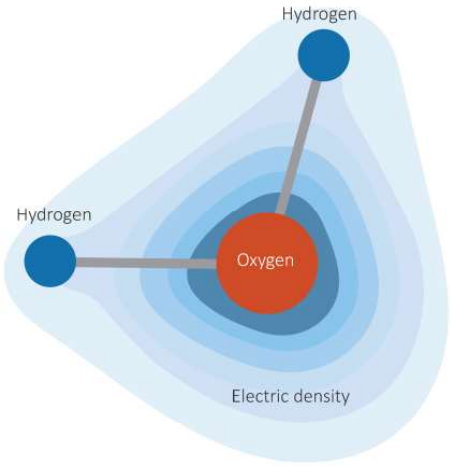


Figure 4: The average electron density around the oxygen atom is about 10x that around the hydrogen atoms.
https://str.llnl.gov/str/October05/gifs/Mundy1.jpg

When the negatively charged oxygen atom in water attracts surrounding positively charged hydrgen atoms, a weak intramolecular force arises called the hydrogen bond. This interaction between water molecules accounts for the various unique properties of water.

Water has a very high melting point, boiling point, surface tension and heat of vaporization compared to others common solvents, because the intramolecular force between the water molecules are weak.In addition, the unique networking of the Hydrogen bonds in water give it more unique properties including: High dielectric constant (the ability of water molecules to surround ions and diminish the attraction of opposite charges for each other), solid state is less density than liquid state and thus has a negative volume of melting[8].

7 https://en.wikipedia.org/wiki/Properties of water
8 https://en.wikibooks.org/wiki/Structural Biochemistry/Unique Properties/Polarity and Hydrogen Bonding

Although hydrogen bonds are weaker than the covalent bonds that hold the structure of the water molecule together, they are nonetheless responsible for various unique physical properties of water. Such properties include its relatively high melting and boiling point temperatures, accounted for by the collection of intermolecular forces between water molecules.

accounted for by the collection of intermolecular forces between water molecules. Thus the hydrogen bonds require a high input of energy in order to break the bonds between molecules. Such weak bonds are crucial to biochemical systems; they are weak enough to be reversibly broken in biochemical processes, yet they are strong enough, when many form simultaneously, to help stabilize specific structures such as the double helix.

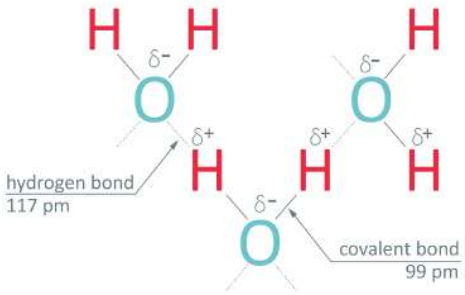


Figure 5: Hydrogen Bonding in Water
http://bryanjovany-chemistry.weebly.com/substance-specific-energy-transfer.html

When water is cooled towards the freezing point, it begins to contract. That is, its density increases until that temperature is a plus 4 degrees Celsius or 39 degrees Fahrenheit. At this temperature, which is right above freezing, water reaches its maximum density. As it is cooled further to 0 degrees Celsius, it does a very strange thing, it expands. Because of this expansion, ice is lighter than water and it floats. If this expansion did not occur, ice would form on the bottom of lakes first and would kill the life forms that live there.

When water begins to freeze, the hydrogen bond begins to form liquid crystal structures. The basic form of these structures is hexagonal. When ice finally forms, it is composed of tetrahedrons that form larger hexagonal structures as those seen in snowflakes.

As ice melts, the hexagonal lattice begins to break apart. Continued heatng continues to break up these hexagon fragments, which allows the molecules to pack more closely. Consequently, the density of cold fresh water actually decreases with increasing temperature until 4° C.

The bond angle between the two hydrogen atom's nucleuses is 104.5 degrees. Some molecules are energized and have an angle of 109.5 degrees. These energized molecules form the basis of the liquid crystal.

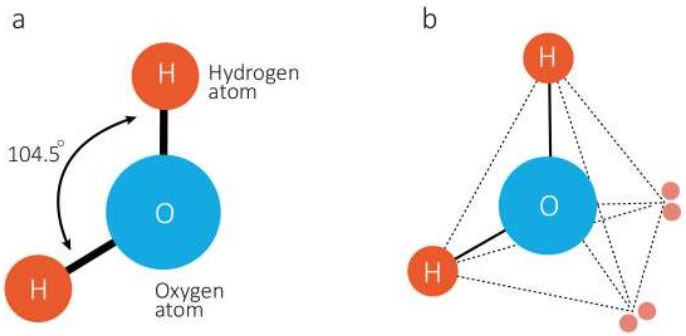


Figure 6: image (a) : The water molecule is bent, with the two bonds between oxygen and hydrogen splayed at an angle of 104.50.The oxygen atom is much larger than the hydrogen atom.image (b) : a water molecule forms approximately a tetrahedron, the four corners of which can form bonds (hydrogen bonds) with other tetrahedral, i.e. with other water molecules. The four corners consist of two hydrogen atoms (H) at one side of the oxygen atom (large sphere), and two lone pairs of electrons at the other side. At the molecular scale, the structure of water is imprinted with this tetrahedral geometry. http://www.metafysica.nl/ontology/general_ontology_29c.html

It might be said that water contains liquid crystals of various bonding. This means that water may change structure depending on the effects of internal or external energy fields. Water's structure changes according to the composition of the containers that hold it[9].

1.2.1 THE PHASE ANOMALIES OF WATER

Water has many anomalous properties that life depends on them. About 70 water anomalies have been identified and these physical characteristics change over time and space, in particular based on atmospheric pressure (Chaplin, 2001).

The boiling point of a substance, according to the laws of physics, is generally related to its molecular weight; that of water strongly depends on pressure. On top of Everest, for example, water boils at a temperature of 68 ° C, at sea level at 100 ° C, while in the depths of the sea it manages to remain liquid despite the high pressures and temperatures. Water freezes at 0 ° C but, if it followed the other liquids of its class (hydrides: composed of elements from the same group as oxygen), the freezing point should be around-100 ° C.

The hydrogen bond is also responsible for the high specific heat of the water(4.187 J/kg °C). By providing heat to the water, this is used not only to increase the temperature, or the kinetic energy of the molecules, but also to break the hydrogen bonds. Providing heat to the water, not is used only increase the temperature, or the kinetic energy of the molecules, but also is breaked the hydrogen bonds.

Providing heat to the water, not is used only increase the temperature, or the kinetic energy of the molecules, but also is breaked the hydrogen bonds.

9 http://www.metafysica.nl/ontology/general_ontology_29c.html

Water has a high latent heat, defined as the amount of energy needed to carry out a phase transition. The heat of vaporization is in fact 2.250 * 106 J / kg, while that of fusion is 3.33 * 105 J / kg.

The climate on earth is largely regulated by the ability of water to absorb and retain heat (latent heat) by controlling and moderating temperature fluctuations.

It is also surprising the relatively low viscosity of water despite the high number of hydrogen bonds. The hydrogen bonds of water, however dense and strong, are easily obviated; the single molecules can easily and quickly change their connectivity, reorganizing themselves in a different way and allowing the mass of liquid to flow quickly, rebalancing any pressure differences in a very short instant.

Water also has an extremely high dielectric constant, which allows it to interact with the electromagnetic fields that invest its molecules, that makes it able to solubilize ionic or highly polar compounds.

Most of the anomalies described above can be traced back to a high difference in electronegativity of its constituent elements (oxygen and hydrogen) and to the fact that the two hydrogen atoms create, with respect to the oxygen to which they are bonded, an angle that is different from 180 ° making the molecule asymmetric and dipolar.

The Anomaly Point of Water:

The density of water is crucial to its behavior. It is at its densest and has its greatest energy content at a temperature of +4°C (39°F). This is the so-called 'anomaly point,' which has a major influence on its quality. Viktor Schauberger called the temperature of +4°C(39°F) the state of indifference of water, meaning that when in its highest natural condition of health, vitality and life-giving potential, water is at an internal state of energetic equilibrium and in a thermally and spatially neutral condition. Above a temperature of +4°C (39°F), water expands. Below this temperature it also begins to expand and become lighter in weight. Because of this ice floats and is able to protect the fish in the water below from extremes of cold[10].

10 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.96

1.3 CHEMISTRY OF NATURAL WATER

The chemistry of water, before human activity on the earth was influenced by the dissolution of minerals from soil, rock, biosynthesis, and biodegradation of organic matter. The chemical compounds that dissolve from minerals, biosynthesis, and biodegradation represent nature or background levels in the water we drink. In some cases natural water can contain elevated concentrations of trace elements (arsenic, fluorine, lead) that are known to be detrimental to human health.

Water that exists at and below the earth's surface is in contact with soil and rock, some mineral or organic matter will be dissolved into the water. For the most part, the chemical elements that will be dissolved in water are generally preordained by their abundance. For example, the average abundance of the most common chemical elements in the earth's crust are oxygen (O), silica (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), magnesium (Mg), and potassium (K). These first eight elements are the building blocks of the most common minerals that make up the earth's crust.

The next 20 most common elements are titanium (Ti), hydrogen (H), phosphorus (P), manganese (Mn), fluorine (F), barium (Ba), strontium (Sr), sulfur (S), carbon (C), zirconium (Zr), vanadium (V), and chlorine (Cl). All combined, these 28 elements make up 99.93 percent of the earth's crust.

When minerals dissolve in water, the chemical elements are usually ionized (i.e., they form a charged chemical species called an ion). These ions occur as either cations (a positively charged ion) or as anions (a negatively charged ion). The major cations and anions that occur in both surface water and groundwater.

Cations	Anions
Na^+ (Sodium)	HCO_3^- (Bicarbonate)
K^+ (Potassium)	SO_4^{2-} (Sulfate)
Ca^{2+} (Calcium)	Cl^- (Chloride)
Mg^{2+} (Magnesium)	SiO_4^{4-} (Silicate and as aqueous SiO_2)

Table 1:Major Cations and Anions Found in Natural Water
The Environmental Science of Drinking Water, 01 ago 2005, p.4

1.3.1 PH OF WATER

Another crucial chemical property of water is its relative acidity or alkalinity. This chemical characteristic has a direct influence on the concentration of minor elements and trace elements that can occur in natural water [Minor elements usually occur in natural water at concentrations less than 1 part-per-million (ppm) but greater than 1 part-per-billion (ppb) or 1 microgram per liter (mg/L), whereas a trace element is usually less than 1 ppb].

acid water will generally tend to have more dissolved trace elements at higher concentrations than alkaline water. Therefore, it is important that the relative acidity or alkalinity be measured by

determining the pH.

The pH of water is the negative logarithm of the hydrogen ion concentration. Although this is the exact definition, it is more important to understand its meaning in everyday use.

Recently, the simplest chemical definition of an acid was proposed by Arrhenius[11] to be a substance containing hydrogen, which, upon its dissolution in water, gives off hydrogen ions (H+) into solution[12].

$$H_2SO_4 = 2H^+ + SO^{-2}_4$$

Bases have been described as substances that when dissolved in water feels soapy or slippery (that is because your skin is being dissolved), have a bitter taste, and can neutralize acids. According to Arrhenius, a base is a substance that gives free hydroxide ions (OH−) when dissolved in water. For example, the ionization of calcium hydroxide would be represented by Equation. In this case, one molecule of calcium hydroxide yields one calcium ion and two hydroxide ions.

$$Ca(OH)^2 = Ca^{+2} + 2OH^-$$

If an acid and base are mixed in equal proportion, the hydrogen ion and hydroxide ion will combine to form water so that there is no hydrogen or hydroxide ions dissolved in water. When such a reaction occurs the water is not acid or alkaline but neutral.

Specifically, a solution is defined as **acidic when the pH is between 0 and 7; neutral at pH equal to 7; at pH between 7 and 14 the solution is alkaline**.

The concentration of hydrogen ions is an important parameter for natural water and waste water. The microorganisms that preside over many biological degradation processes tolerate only modest variations with respect to the optimal range (6.5- 8.5). Consequently, very high or very low values can cause serious damage to the receiving water body.

Alkalinity is the ability of water to neutralize acids by buffering a drop in pH thanks to the presence of carbonates, bicarbonates and hydrates.

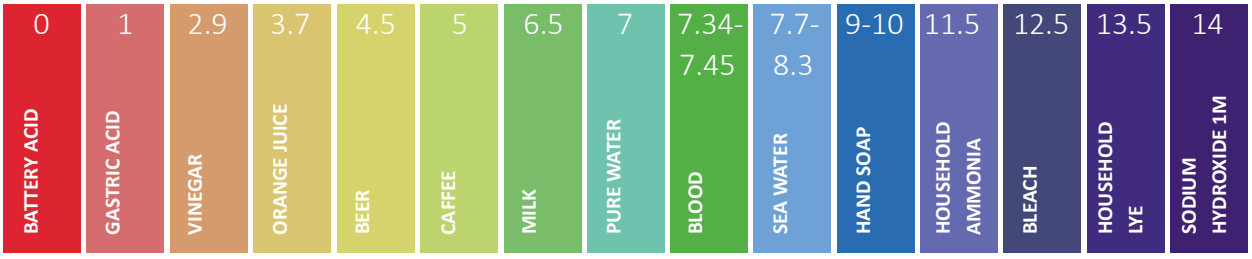


Table 2:Representative ph value

11 Dr.Svante Arrhenius received the 1903 Nobel Prize in chemistry for the development of ionic theory, which he applied to the definition of acids and bases.
12 Patrik J.Sullivan, Franklin J.Agardy, James J.J.Clark, The Environmental Science of Drinking Water, 01 ago 2005, p.4-5

Today, water hardness is defined as the 'overall content of dissolved calcium and magnesium salts in the water (ECG)' (Treccani).

Hardness salts are usually present in water as sulphates, chlorides, nitrates, carbonates or hydrogen carbonates, which are generally soluble but precipitate upon heating or evaporation forming limestone or other types of encrustations. Hardness is generally expressed in French degrees (° f, not to be confused with ° F, which are degrees Fahrenheit), where one degree represents 10 mg of calcium carbonate ($CaCO_3$) per liter of water (1 °f = 10 mg/l = 10 ppm).

Currently, the **MEC** grade is also used, which corresponds to 1 g of CaCO3 in 100 liters and is therefore equal to the French grade.

The data taken from Clark (1908) can be considered to generally represent the natural mineral content of river water before the explosive growth of the chemical industry in the early 1900s. These data show that, for the most part, river water is dominated by calcium and bicarbonate. This result is consistent with rock-weathering trends (i.e., Fe, Al, and Si tend to occur in less water-soluble minerals), the influence of carbon dioxide in the atmosphere on water chemistry, and the common occurrence of calcium carbonate minerals in rock and soil. These data generally show that metal cation concentrations have the sequence Ca > Na > Mg > K > Fe and Al, while the anion concentration sequence is HCO3 > SO4 > Cl.

	ppm									
River	HCO_3	SO_4	*Cl*	*Ca*	*Mg*	*Na*	*K*	SiO_2	Fe_2O_3	Al_2O_3
St. Lawrence, Montreal	44.43	11.17	2.41	20.67	6.44	4.87	nr	10.01	nr	nr
Genesse, Rochester, NY	37.94	25.29	1.47	24.48	5.29	2.59	1.35	0.82	0.83*	
Merrimac, Concord, NH	28.15	12.78	8.78	17.14	4.18	6.16	trace	18.14	3.33	1.34
St. James, Richmond, VA	42.52	5.26	1.51	18.49	5.44	3.52	3.58	14.74	0.96	0.58
Mississippi, Minneapolis, MN	47.04	9.61	0.85	20.59	7.67	5.33*		8.01	0.05	nr
Mississippi, New Orleans, LA	34.74	14.90	6.23	20.42	5.21	4.92	4.65	6.77	0.15	0.44
Kentucky, Frankfort, KY	39.06	7.32	1.42	22.62	4.06	5.71*		15.32	0.94	nr
Missouri, Great Falls, MT	27.10	25.45	7.62	8.93	5.48	17.13*		8.29	nr	nr
Kansas, Lawrence, KS	23.83	18.15	18.80	14.76	3.51	15.45	nr	4.83	0.67*	
Arkansas, Little Rock, AR	10.80	12.61	38.55	7.60	1.67	25.92	0.74	1.81	0.06	0.24
Brazos, Waco, TX	8.83	20.74	33.71	9.54	2.04	23.27*		1.69	0.03	nr
Salt, Mesa, AZ	9.61	8.29	41.56	7.15	2.69	26.38	1.38	2.94	nr	nr
Sacramento, Sacramento, CA	27.36	16.24	7.18	12.34	5.83	10.05	1.26	16.69	3.05*	
Yukon, Eagle, AL	46.16	10.75	0.41	22.21	4.71	6.14	trace	7.78	nr	1.48
Elbow, Calgary, Canada	44.66	18.80	0.56	24.39	6.55	2.77	0.42	1.85	trace	nr
Plata, Buenos Aires, Brazil	11.59	17.97	18.11	3.71	1.42	24.89	nr	10.82	4.81*	
Rio de Arias, Salto, Argentina	39.13	13.24	2.77	19.63	5.20	1.82	5.75	11.57	0.89	nr
Seine, Bercy, France	39.78	8.57	2.95	29.13	0.63	2.87	0.86	9.59	0.99	0.19
Rhone, Geneva, Switzerland	27.92	23.18	0.55	24.89	1.48	2.75	0.88	13.08	nr	2.14
Rhine, Strassburg, France	36.69	8.38	0.52	25.30	0.61	2.17	0.66	21.07	2.51	1.09
Moldau, Prague, Czech Rep	32.86	11.95	10.69	13.52	4.88	10.22	5.19	8.96	1.26*	
Elbe, Celakowitz, Czech Rep	45.87	8.95	3.27	26.41	3.21	3.93	2.46	4.09	0.91*	
Danube, Regensburg Germany	51.70	8.54	1.31	27.40	6.00	1.12	0.72	2.42	0.06	0.42
Lago di Garda, northern Italy	53.29	4.17	3.13	24.56	6.66	2.49	2.01	2.33	0.15	1.21
Klarelf, Sweden	38.68	7.63	2.24	11.67	0.51	8.42	3.78	19.17	7.44*	
Om, Omsk, Russia	43.73	2.15	12.81	11.24	9.68	9.64	2.28	6.51	1.42	nr
White Nile, Khartoum, Sudan	42.97	0.25	4.58	9.78	3.00	17.66	6.79	14.72	nr	nr

Table 3:: Data on the Mineral Content of River Water Elemental data for Na and K are combined and Fe and Al are combined.Adapted from Clark, 1908

Clark (1908) also provided data on the chemistry of groundwater, but focused on mineral water from springs and wells, as they have "the greatest commercial importance." According to Clark

(1908), “all springs are mineral springs, for all contain mineral impurities; but in a popular sense the term is restricted to waters of abnormal or unusual composition.” The analyses provided by Clark (1908) are grouped by the dominant anion (i.e., chloride, sulfate, bicarbonate).

	ppm														
Mineral Water	HCO_3	SO_4	*Cl*	*Br*	*I*	AsO_4	*Ca*	*Mg*	*Ba*	*Sr*	*Na*	*K*	SiO_2	Fe_2O_3	Al_2O_3
Artesian well, Abilene, KN	nr	0.07	61.59	0.29	nr	nr	4.85	1.52	nr	nr	31.57	trace	trace	nr	nr
Montesano Springs, MI	nr	nr	57.38	0.31	nr	nr	6.15	2.09	nr	nr	28.17	0.15	0.17	nr	nr
Utah Hot Springs, Ogden, UT	0.61	0.94	58.79	trace	nr	nr	4.90	0.40	nr	nr	30.38	3.76	0.20	nr	nr
Spring at Pahua, New Zealand	0.17	0.15	60.78	trace	0.11	nr	3.14	0.60	nr	nr	34.81	0.02	0.12	trace	nr
Water of Salsomaggiore, Italy	nr	0.18	61.09	0.15	0.03	nr	3.21	0.82	nr	0.24	34.04	nr	0.01	0.03	0.01
Harrogate Spa, England	2.12	nr	58.81	0.19	0.01	trace	2.65	1.37	0.42	trace	36.18	0.48	0.07	nr	trace

Table 4:Data on Chloride Dominated Mineral Waters
Adapted from Clark, 1908

	ppm														
Mineral Water	CO_3	SO_4	*Cl*	H_3AsO4	*Ca*	*Mg*	*Na*	*K*	PO_4	*Mn*	*Fe*	*Cu*	SiO_2	*Zn*	*Cd*
Spring															
Joplin, MO	8	53	.48	nr	11.32	.71	.67	.46	nr	.42	.11	.04	2.54	22	.1
Mine Water															
Mo Zn Reg.	nr	63.3	.03	nr	3.55	.26	.5	tr	nr	.02	4.88	.04	1.11	25	.09
Cottage Well															
England	6.5	57	6.56	nr	8.33	7.03	13.5	.48	nr	tr	tr	nr	.16	nr	nr
Spring, Bosnia	nr	65	.48	nr	3 1	48	.31	.32	tr	.12	25	.36	1.7	.3	nr
So. Tyrol	nr	71	.03	1.93	7	1	1.25	.23	.23	.78	.03	.15	1.61	.06	nr

Table 5:Data on Sulfate Dominated Mineral Waters
Adapted from Clark, 1908

	ppm											
Mineral Water	CO_3	HCO_3	SO_4	*Cl*	*Ca*	*Mg*	*Na*	*K*	PO_4	*Mn*	*Fe*	SiO_2	AL_2O_3
Private well													
Missouri	nr	1,287	88	94	4	2	581	nr	nr	nr	nr	12	nr
Artesian													
Lajunta, CO	791	nr	71	67	4.4	2.5	669	669	nr	tr	2.4	51	3.4
Spring Water													
Brit. Col.	nr	6,339	60	1.5	117	1,152	52	12	tr	nr	6.7	83	6.5
Silesia													
Austria	nr	405	6.5	1	66	19	5.2	1.8	.54	.05	47	69	.3

Table 6:Data on Carbonate Dominated Mineral Waters
Adapted from Clark, 1908

	ppm												
Mineral Water	CO_3	SO_4	*Cl*	*Ca*	*Mg*	*Na*	*K*	PO_4	*Fe*	SiO_2	AL_2O_3	NH_4	NO_3	B_4O_7
Hot Spring														
Clear Lk., CA	22	tr	16.5	tr	tr	25	tr	nr	nr	2.6	.40	7.9	nr	25.6
Phosphatic Water														
France	19.5	7.7	5.1	30.4	1.2	3.3	tr	22.4	.04	4	nr	nr	6.3	nr
Holy Well														
Mecca, Arabia	12.8	14	16	48	72.7	12.7	6.7	nr	nr	1.4	nr	nr	24.6	nr

Table 7:Data on Mixed Anion Mineral Waters-
Adapted from Clark, 1908

	Median	Median
Cations	**Surface water (mg/L)**	**Groundwater (mg/L)**
Calcium	15	50
Sodium	6.3	30
Magnesium	4.1	7
Potassium	2.3	3
Anions		
Bicarbonate	58	200
Silica (aqueous)	14	7.4
Chloride	7.8	20
Sulfate	3.7	30
Minor Elements (less than 1 ppm but greater than 1 ppb)		
Aluminum	Lead	
Arsenic	Lithium	
Antimony	Manganese	
Barium	Molybdenum	
Boron	Phosphorus	
Beryllium	Rubidium	
Bromine	Strontium	
Chromium	Titanium	
Fluoride	Vanadium	
Iodine	Zinc	
Iron		
Trace Elements (less than 1 ppb)		
Cadmium		
Cobalt		
Cesium		
Gold		
Mercury		
Nickel		
Selenium		
Silver		
Tin		
Thallium		
Tungsten		
Uranium		

Table 8:Water Chemistry of Natural Water
Adapted from Langmuir, 1997

1.4 BEHAVIOUR OF WATER IN THE HISTORY

It is interesting to rediscover the value and symbolic aspect of water in ancient cultures but also the treatment techniques adopted when energy sources and technologies were not yet available, which today lead to an often careless use of this precious resource.

Each traditional technique, inventoried and safeguarded, constitutes an extraordinary patrimony of experience and knowledge, today in danger, which can be disseminated and reused. However, it is not a question of reproducing the solutions slavishly in every context but of adopting, even using advanced technologies, the logic in charge of them.

Sustainable management of the territory and cities will be come from the application of these

principles drawn from the lesson of tradition. This has always been a dynamic system capable of incorporating innovation, subjected to long-term scrutiny and local and enviromental sustainability. Traditional knowledge is re-proposed as appropriate and advanced innovative knowledge, for the development of a new technological paradigm(Lauretano, 2001).

The new challenges imposed by the increase in population, by climate change, by the scarcity of water resources will spontaneously rediscover certain ancient techniques and knowledge of water treatment. these criticalities have forced local populations to develop particular attention and creativity in the use of this fundamental resource for their life.

Today it seems obvious to obtain water easily for daily use, but in the past it cost effort and effort to obtain it and its overall value was much higher. In ancient times it was revered in worship, men perceived in it the presence of divine entities that had to be approached only with great respect, often the mythologies begin with aquatic divinities.

History has shown us in the past water was considered in different cultures and religions in a very similar way to what modern theories of quantum physics describe it today: substance of life and matrix of information.

One interpretation of this passage is that Heraclitus (530-470 BC) is saying:*" we can't step into the same river twice. This is because the river is constantly changing. If I stroll down the banks of the Danube, the water before my eyes is not the same water from moment to moment. If the river is this water (which is a debatable point – the river could be its banks, the scar it carves in the landscape, but let's leave this aside), it follows that the Danube is not the same river from moment to moment. We step into the Danube; we step out of it again. When we step into it a second time, we step into different water and thus a different river"*[13].

Thales (ca. 625-550 BC) is recognized for breaking from the use of mythology to explain the world and the universe, instead explaining natural objects and phenomena by offering naturalistic theories and hypotheses. Almost all the other pre-Socratic philosophers followed him in explaining nature as deriving from a unity of everything based on the existence of a single ultimate substance instead of using mythological explanations. Aristotle regarded him as the founder of the Ionian School of philosophy, and reported Thales' hypothesis that the originating principle of nature and the nature of matter was a single material substance: water[14].

Aristotle (384–322 BC):*" Salt water when it turns into vapour becomes sweet, and the vapour does not form salt water when it condenses again. This I know by experiment. The same thing is true in every case of the kind: wine and all fluids that evaporate and condense back into a liquid state become water. They all are water modified by a certain admixture, the nature of which determines their flavour"*[15].

Aristotle's quotes of saline water filtering :*"There is more evidence to prove that saltness [of the sea] is due*

13 Kahn, C. H., 1979, The Art and Thought of Heraclitus, Cambridge: Cambridge University Press. Laks, André and Glenn W. Most, 2016, Early Greek Philosophy, vol. 3, Cambridge, Mass.: Harvard University Press.
14 Aristotle. "Book I 983b". Aristotle, Metaphysics. Perseus Project.
15 Aristotle, (2014). "Complete Works of Aristotle, Volume 1: The Revised Oxford Translation", p.582, Princeton University Press

to the admixture of some substance, besides that which we have adduced. Make a vessel of wax and put it in the sea, fastening its mouth in such a way as to prevent any water getting in. Then the water that percolates through the wax sides of the vessel is sweet, the earthy stuff, the admixture of which makes the water salt, being separated off as it were by a filter"[16].

It is said that Alexander the Great, having conquered Egypt, found in the Tomb of Hermes Trismegistus, founder of the science of the ancients, an emerald tablet on which an engraving revealed the essence at the origin of all things: *"True, without error, certain and most true; that which is above is as that which is below, and that which is below is as that which is above, for performing the miracles of the One Thing; and as all things were from one, by the mediation of one, so all things arose from this one by adaptation; the father of it is the Sun, the mother of it is the Moon; the wind carries it in its belly; the nurse thereof is the Earth. This is the father of all perfection, or consummation of the whole world. The power of it is integral, if it be turned into earth. Thou shalt separate the earth from the fire, the subtle from the gross, gently with much wisdom; it ascends from earth to heaven, and again descends to earth; and receives the strength of the superiors and of the inferiors—so thou hast the glory of the whole world; therefore let all obscurity flee before thee. This is the strong fortitude of all fortitudes, overcoming every subtle and penetrating every solid thing. So the world was created. Hence were all wonderful adaptations of which this is the manner. Therefore am I called 'Thrice Great Hermes,' having the Three Parts of the philosophy of the whole world. That which I have written is consummated concerning the operation of the Sun."*

"The soul of man is like to water; from Heaven it cometh, to Heaven it riseth And then returning to earth, forever alternating".(Johann Wolfgang von Goethe)[17]

According to Vitruvius, in ancient Egypt the Pharaohs prostrated themselves in front of an urn full of water located in the most hidden place of the pyramid. It might be interesting to relate this information with the hypotheses advanced by Mario Pincherle regarding the theory of the Zed, a granite monolith contained within the Pyramid of Keope, inside which is the sarcophagus containing an urn inside which they were recorded electromagnetic anomalies.

In China, water has been an essential ingredient in personal hygiene, ritual practice, and political ceremony from the most ancient times[18]. These associations are likely to have begun as early as the Shang (ca. 1600–ca. 1046 BCE), for it is said that the posthumous name of the dynastic founder— Tang 湯, literally meaning "hot water"—likely was given to him due to his role in the ritual cleansing of evil. water was also understood in early China to have salubrious effects on the physical body. It was instrumental, for example, in regulating the body temperature in order to counter the deleterious effects of seasonal changes[19]. The seminal medical treatise, the Inner Canon of the Yellow Emperor (Huangdi neijing 黃帝內經), which was compiled in the first century BCE and is still considered a foundational text of Chinese medicine today, echoes the notion that water is good for one's health[20].

16 Aristotle, (2014). "Complete Works of Aristotle, Volume 1: The Revised Oxford Translation", p.583, Princeton University Press
17 Johann Wolfgang von Goethe (1882). "The Poems of Goethe", Richard West
18 See Edward Schafer, "The Development of Bathing Customs in Ancient and Medieval China and the History of the Floriate Clear Palace," Journal of the American Oriental Society vol. 76, no. 2 (1956): 57–82
19 Schafer, "The Development of Bathing Customs," 64.
20 On the history and contents of this text, see Paul U. Unschuld, Huang Di Nei Jing Su Wen: Nature, Knowledge, Imagery in an Ancient Chinese Medical Text (Berkeley and Los Angeles: University of California Press, 2003).

In addition to referring to actual fluids in the body, water also appears in medical discourses as one of the "five phases" or "five processes" (wuxing 五行). This foundational doctrine emerged in the fourth to third century BCE as a moral theory and was further developed through the early Han in order to explain the optimal functioning of qi (i.e., the vital energy or essence of the cosmos) within politics, the human body, and other complex systems. According to the mature five-phase doctrine, qi manifests in five discrete temporal phases or stages that correspond with the qualities of wood, fire, earth, metal, and water. These phases can unfold in generative or destructive cycles that govern how qi transforms and manifests in the material world. Qi manifesting with a watery quality, for example, could both vanquish the influences of fire and feed the emergence of wood. Water, in this system, represented a quiescent or dormant phase, a time for regrouping and reconsolidating.

Figure 7: China
www.joelsantos.net

Water's correlating organs were kidney and bladder, its sense hearing, its flavor salty, its season winter. It was associated with the moon, with cold temperatures, with the color black, with the planet Mercury, and with the pig and rat zodiac signs. Throughout the imperial period, understanding and capitalizing on these and many more connections—a process that scholars have generally referred to as "correlative thinking"— was central to the theories behind an array of Chinese arts and techniques practiced by ritual technicians (fangshi 方士), masters of geomancy (fengshui 風水), adepts at self-cultivation (yangsheng 養生), Daoist priests, and numerous other practitioners of Chinese religious and healing traditions.

During the Ming dynasty, in his work "Compendium of Materia Medica" (Bencao Gangmu), Li Shizhen presents a revolutionary concept of "water tonic and water care". "According to him, water is the source of all changes like the father; the Earth is the source of all things, like the mother ".

Therapeutic uses for water appear also in the context of the classical Indian Ayurvedic medical tradition. Coalescing in the first six centuries CE, but incorporating a range of medical opinions from the last centuries BCE, the three most influential Ayurvedic treatises (Caraka-samhita, Susruta-samhita, and Astangahrdaya-samhita) agree that bathing in water is an effective means of fighting exhaustion, stimulating digestion, enhancing sexual potency, and strengthening the body,

among other boons.[21] However, the tradition also distinguishes between different types of water for different medicinal applications. For example, according to the Caraka-samhita, water drawn in late winter can be used to cure phlegm and wind, while the best for those of delicate constitutions is water drawn in the autumn. Water originating in the Himalayas and Malaya are best, while one should avoid water from Pariyatra, Vindhya, and Sahya, as it can cause diseases[22].

In Ayurveda, as in certain schools of Indian philosophy, water is understood not only as a curative substance, but also more generally as representing one of the four "great elements" (mahabhuta). As a great element, water is one of the essential building blocks that make up the phenomenal world, as well as one of the fundamental components or constituents (dhatu) of the human body. While earth, fire, wind, and space elements make up the solids, heat, movement, and empty voids of the physical structure respectively, the water element makes up the manifold liquids that flow through the body's tubes and ducts[23].

Figure 8: Bhutanatha Lake, Badami, India. Photograph: Chris Lisle/Corbis

Early Buddhist texts also engage with the doctrine of the great elements. Written down in the Pali language in first-century BCE Sri Lanka, these texts are reflective of earlier oral traditions from northeastern India and may possibly ultimately be connected with the same intellectual milieu as the Ayurvedic treatises. While they may have enthusiastically adopted medical descriptions of the role of the water element in human anatomy and physiology, these early Buddhist writers seem to have been somewhat more ambivalent about bathing in it. The Buddha forbade his followers to engage in self-beautification practices and other "worldly arts" (tiracchana-vijja), such as bathing in perfumed water or "giving ceremonial mouthwashes and ceremonial bathing," which he deemed unworthy behavior for an ascetic in his order.[24] On the other hand, Buddhist literature in many places also suggests that close attention to personal cleanliness—including regular bathing, teeth brushing, and washing of clothing—was recognized as important for prevention and treatment of various ailments.

21 e.g., Caraka 1.5 (translated in P. V. Sharma, Caraka-samhita, [Varanasi: Chaukhambha Orientalia, 2007–2008], vol. 1, 40);
22 Caraka 1.27 (translated in Sharma, Caraka-samhita, vol. 1, 211–12).
23 Caraka 4.8 (translated in Sharma, Caraka-samhita, vol. 1, 460).
24 MN 28, "Maha-hatthipadopama Sutta: The Great Elephant Footprint Simile," translated by Thanissaro Bhikkhu, accessed April 21, 2017, https://tinyurl.com/p933bv4 (edited for punctuation and clarity).

In Indian mythology, water, rich in germs, fertilizes the earth, precedes all creation. On the primordial waters floated Narayana, from whose navel the cosmic tree sprouted; one after the other the other gods are born: Veruna, Prajapati, Purusa or Brahman who always express the same myth of water.

Water thus becomes a magical substance, a medicine par excellence capable of healing, rejuvenating and ensuring eternal life. The fountains of youth in which "living water" is found are able to give life, vigor and eternity. Even today in India, diseases are thrown into the water that absorbs evil thanks to its power to disintegrate and assimilate all forms.

Everything that is immersed in it "dies" and coming out is like a sinless child able to start a new life. For this reason, in India the dead are cremated on a pyre floating in the sacred water of the Ganges.

According to the Indian tradition, water is considered sacred, but we do not pray to it as such but rather we turn to the source of life and spirituality within it. It is therefore considered as purified and at the same time as a purifier and source of material and spiritual life (Baartmans).

Water, in most ancient cultures and religions, has always been associated with a state of the human condition to be pursued or maintained purity.

In this sense, ritual immersion (including the Miqvè) takes on great significance in the Jewish tradition; the body must be touched entirely by water (hence the repetition of the immersion three times) and not by any water: only rainwater, that is, not contaminated by previous uses of man.

With the advent of Christianity, many images related to water and purity remain, however, alongside the preponderant idea of salvation and redemption of humanity. Purity (salvation) is no longer occasional, to be sought or restored every time you want to get in touch with the Divinity: it is eternal.

Baptism is not just material purification like the immersion of Jewish tradition; it is the regenerating element of humanity that seals the new covenant with God, the testimony of the divine incarnation in a man which took place in the baptism of Jesus.

In Islam, life and knowledge originated from water, a divine gift that symbolises profound wisdom, the drink that quenches the soul's thirst. But it is also science. Thus, the word al-ma'a – water in Arabic – appears 63 times in the Quran, which revealed secrets in the 7th century recently discovered by science.

Do not the Unbelievers see that the heavens and the earth we joined together (as one Unit of Creation), before we clove them asunder? We made from water every living thing (Quran, 21-30).

And God has created every animal from water: of them there are some that creep on their bellies; some that walk on two legs; and some that walk on four. God creates what He wills; for verily God has power over all things (Quran, 24-45).

Water also represents also purity in Islam. Thanks to water human beings take care of their body hygiene, as in all cultures, but also perform spiritual purification by means of the daily ablutions. In accordance with the great Sufi Ibn 'Arabi of Murcia, who lived in the 12th and 13th centuries, by performing ablutions believers get rid of vanity and appearing themselves as servants of the Creator.

The existence of facilities for ablutions shows how these were most likely used in purification rites such as sprinkling and pouring water; this aspect is omnipresent in various religions: the desire for a "sacred purification" to remove any kind of impediment to people entering the sphere of the sacred is a deeply felt need (Edlund, 1987).

1.5 CLASSIFICATION THE TYPES OF WATER

The volume of the planet's water is concentrated in the seas and oceans and constitutes around 1350 million km3.This is salt water, with an average mineralization of 35.0 g/L, which makes it unsuitable not only for drinking but also for agriculture needs. Fresh water is localized mainly in the North and South poles and in the mountains in the form of glaciers. This resource constitutes 30–50 million km3. However, this source of fresh water is almost unobtainable for human use.

Water appears on earth in different forms:

1.5.1 RAINWATER

Rain is water droplets that have condensed from atmospheric water vapor and then fall under gravity. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides water for hydroelectric power plants, crop irrigation, and suitable conditions for many types of ecosystems. The major cause of rain production is moisture moving along three-dimensional zones of temperature and moisture contrasts known as weather fronts. If enough moisture and upward motion is present, precipitation falls from convective clouds (those with strong upward vertical motion) such as cumulonimbus (thunder clouds) which can organize into narrow rainbands. In mountainous areas, heavy precipitation is possible where upslope flow is maximized within windward sides of the terrain at elevation which forces moist air to condense and fall out as rainfall along the sides of mountains.[25]

Rainwater is the purest naturally available water, if it has not been affected by industrial pollution (acid rain). Slightly richer through the absorption of atmospheric gases, it is still unsuitable for drinking in the long term. When drunk as melted snow-water, it also gives rise to certain deficiencies and if no other water is available it can on occasion result in goiter, the enlargement of the thyroid gland[26].

1.5.2 SURFACE WATER

Surface water is water located on top of land forming terrestrial (inland) water bodies, and may also be referred to as blue water, opposed to the seawater and water bodies like the ocean. The vast majority of surface water is produced by precipitation. As the climate warms in the spring, snowmelt runs off towards nearby streams and rivers contributing towards a large portion of human drinking water. Levels of surface water lessen as a result of evaporation as well as water moving into the ground becoming ground-water. Alongside being used for drinking water, surface water is also used for irrigation, wastewater treatment, livestock, industrial uses, hydropower, and recreation[27]. surface water is considered freshwater when it contains less than 1,000 milligrams per liter (mg/L) of dissolved solids[28].

25 https://en.wikipedia.org/wiki/Rain
26 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.98
27 United States Environmental Protection Agency (2017-11-02). "Fresh Surface Water". US EPA. Retrieved 2020-04-06.
28 U.S Department of the Interior. "Surface-Water Use". www.usgs.gov. Retrieved 2020-04-06.

Surface water includes water from dams and reservoirs that contain some minerals and salts absorbed through contact with the soil and the atmosphere. Its quality deteriorates through exposure to the Sun, to excessive warming and to chemicals and other pollutants. Although most urban communities now depend on this source, generally speaking it is not good quality water.

1.5.3 GROUND WATER

Groundwater is the water present beneath Earth's surface in rock and soil pore spaces and in the fractures of rock formations. About 30 percent of all readily available freshwater in the world is groundwater[29]. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become completely saturated with water is called the water table. Groundwater is recharged from the surface; it may discharge from the surface naturally at springs and seeps, and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal, and industrial use by constructing and operating extraction wells. The study of the distribution and movement of groundwater is hydrogeology, also called groundwater hydrology.

Groundwater is hypothesized to provide lubrication that can possibly influence the movement of faults. It is likely that much of Earth's subsurface contains some water, which may be mixed with other fluids in some instances.

Groundwater is often cheaper, more convenient and less vulnerable to pollution than surface water. Many municipal water supplies are derived solely from groundwater.[30]

1.5.4 JUVENIEL WATER

Juvenile water is immature water from deep underground sources, like geysers. It has not mellowed sufficiently on its passage through the ground. It has not developed a mature structure and contains some minerals (geospheric elements), but few gases (atmospheric elements). Juvenile water reaching the crust mixes with water of different origin found there. An increased content of carbon dioxide, helium, and oxygen in groundwater is an indirect indicator of juvenile water. So as drinking water it is not very high grade.[31] [32]

29 "What is Groundwater? | International Groundwater Resources Assessment Centre". www.un-igrac.org. Retrieved 2022-03-14.
30 The USGS Water Science School. United States Geological Survey. 23 May 2013. Retrieved 21 Jan 2014.
31 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.98
32 Kadik, A. A., E. B. Lebedev, and N. I. Khitarov. Voda v magmaticheskikh rasplavakh. Moscow, 1971

1.5.5 SPRING WATER

A spring is a point of exit at which groundwater from an aquifer flows out on top of Earth's crust (pedosphere) and becomes surface water. It is a component of the hydrosphere. Springs have long been important for humans as a source of fresh water, especially in arid regions which have relatively little annual rainfall.

Springs are driven out onto the surface by various natural forces, such as gravity and hydrostatic pressure. They vary in volumetric flow rate from nearly zero to more than 14,000 litres per second (490 cu ft/s) for the biggest springs.[33]

True spring water has a large amount of dissolved carbons and minerals. Its high quality is often shown by its shimmering, vibrant bluish color. The product of infiltrating rainwater (full complement of atmospheric gases) and geospheric water (full complement of minerals, salts and trace elements). The more calcium and magnesium ions that are dissolved in water, the harder it is said to be; water with few dissolved calcium and magnesium ions is described as being soft. This is the best water for drinking, and it often retains this quality in the upper reaches of a mountain stream.[34]

1.5.6 DISTILLED WATER

The pure, distilled water is missing a lot of components. Compared to conventional water, for example, with river water, the distillate water is missing a whole range of dissolved salts and gases. This kind of water, extract or attract to itself all the substances it needs to become mature itself, and therefore absorbs everything within reach. Distilled water is a colorless, limpid liquid, without odor or taste, and of neutral reaction. On evaporating one liter of distilled water no fixed residue should remain[35].

Such water is really quite dangerous if drunk continuously long-term. The 'Kneipp cure' uses distilled water for its short-term therapeutic effect, where it acts to purge the body of excessive deposits of particular substances[36].

33 "Te Waikoropupū Springs". New Zealand Department of Conservation. Retrieved 6 February 2022.
34 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.99
35 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.98
36 http://chestofbooks.com/food/beverages/A-Treatise-On-Beverages/Properties-And-Tests-Of-Distilled-Water.html#.VbYE4_ntnxp

1.6 WATER MEMORY

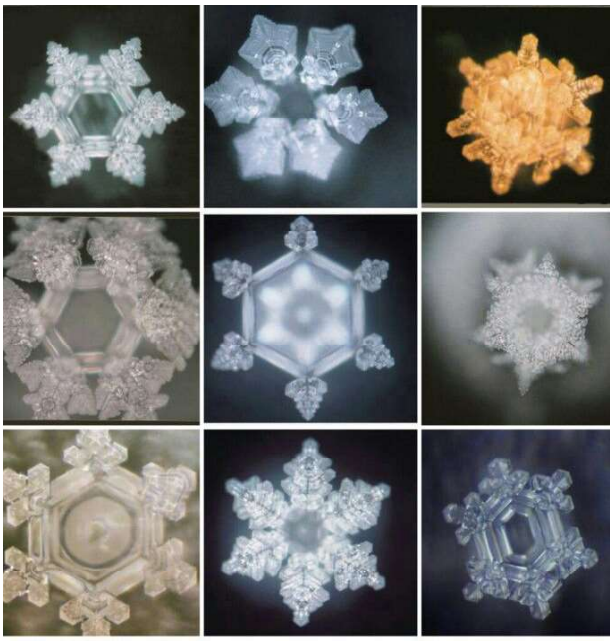


Figure 9: water crystals formed when words like peace or love were written on paper and taped to the containers.
Pics from "The Hidden Messages in Water" by Matsura Emoto.

In 1985, the late Jacques Benveniste, a French biologist, conducted experiments that purported to show that a certain type of cellular immune response could be brought about by an anti-immunoglobulin agent that had been diluted to such an extent that it is highly unlikely that even one molecule of this agent remained in the aqueous solution. He interpreted this to indicate that water could somehow retain an impression, or "memory", of a solute that had been diluted out of existence. This result was immediately taken by believers in homeopathy as justification for their dogma that similarly diluted remedies could be effective as alternative medical agents. The consensus among chemists is that any temporary disruption of the water structure by a dissolved agent would disappear within a fraction of a second after its removal by dilution, owing to the vigorous thermal motions of the water molecules. Benveniste's results have never been convincingly replicated by other scientists[37].

The theme of the memory of water is a much debated issue and strongly opposed by the scientific community, which deems the theories developed in support of it without any foundation.

The experiments of prof. Giorgio Piccardi (1962) on activated water led to the recognition of water, in temperatures where life is possible, must be considered a quasi-crystal capable of assuming some specific conformations capable of being "activated" by electromagnetic fields, producing peculiar property that's named "memory".

In 1995 Benveniste, he devoted himself to a new series of experiments using a computer equipped with a sound card. The device was equipped with a sensor positioned near the source tube, containing the solution of an active ingredient (ovalbumin or acetylcholine) in a weight dose. The signals emitted by the solution were amplified, transformed into digital signals, and then sent to the computer's hard drive to be saved. Once the signal was recorded, a receiver tube to be "informed" was placed in contact with a coil connected to the computer. The digital signal, amplified again and reconverted into waves thanks to the coil, was transmitted to the receiver tube.

The water from the latter was then injected into an isolated guinea pig heart to test its effects. The success of the experiments conducted with the aid of the computer, whose sound card recorded only frequencies below 20,000 hertz, thus revealed that the electromagnetic signals transmitted by the molecules belonged to the low frequencies (the same as those of the human voice and mu-

37 https://en.wikipedia.org/wiki/Jacques_Benveniste

sic). he then explained the phenomenon observed in the high dilutions with the communication between the biomolecules and their receptor molecules, through the emission of low frequency electromagnetic signals, which the receptors pick up like a radio tuned to a specific wavelength[38].

The hypothesis according to which molecules communicate through specific electromagnetic signals does not contradict the principles of structural biology at all, but complements them. It allows to explain both the mechanism of classical biological reactions (the molecules exchange electromagnetic messages without any need for physical contact), and the action of high dilutions (the only signal stored by the water, then reproduced, is sufficient to generate a chemical and biological process). Therefore, the world we live in is not "Other" at all (the electromagnetic one, which we replace the ancient molecular).

actually, what we do is capture, duplicate and transfer the electromagnetic signals emitted by molecules in their normal function. We will soon be able to edit them too!

Water is nothing more than a vector of information. Nothing revolutionary: it is through the low frequency Hertzian waves that submarines are able to communicate with the surface.

Benveniste, 2005 explains the "memory of water" like this: "*this is more mysterious. But no more than its very existence: a liquid (at normal temperature and pressure) formed by gas (oxygen and hydrogen), which expands when heated and solidifies when it cools!* "

According to the observations of Dr. Igal Bar Ilan of the Galilee Technology Center, Israel, a molecule, when it enters the water, would form a unicum with the solvation shell of water molecules, assuming a different behavior than when the molecule is outside it.

Spaggiari and Trebbia, 2007: *"The water molecules imprison the foreign molecule, surround it forming a shell (solvation shell) or a niche and create a copy; even when this foreign molecule is completely destructured or filtered and therefore the niche is empty , it seems that the clusters keep its shape, its perfect imprint and record its information in terms of vibrations ".* Based on these observations, therefore, there would exist short and long distance interactions capable of binding the water molecules in coherence domains, allowing at the same time to preserve the structure they possessed in the presence of a solute, even after the disappearance of the last.

Furthermore, numerous physics studies indicate that water molecules can form aggregates or polymers through hydrogen bonds. These are rather unstable structures. Recently Emilio del Giudice and his Working Group have shown and proposed how water can be organized into networks of Coherence Domains, which involve millions of water molecules that are the size of nanostructures (Del Giudice et.al., 2009).

Furthermore, numerous physics studies indicate that water molecules can form aggregates or polymers through hydrogen bonds. These are rather unstable structures. Recently Emilio del Giudice

38 https://sites.google.com/site/appliedmemwaterresearch/jacques-benveniste

and his Working Group have shown and proposed how water can be organized into networks of Coherence Domains, which involve millions of water molecules that are the size of nanostructures (Del Giudice et.al., 2009).

The studies on the memory of water described here are in contrast with the commonly accepted theories on the behavior of liquid water, highlighting aspects that are still little known. This is not the place to confirm or not the validity of these hypotheses but, as stressed several times, it is interesting, for the purposes of this thesis and not only, to deepen and take into account these emerging properties when dealing with such a resource. fundamental, which still has many dark sides. If the properties of water to “memorize” biological information were confirmed, absolutely new and shocking scenarios would open up, which would entail a radical change of paradigm on the vision of life.

2 QUALITY OF DRINKING WATER

> VALUTATION OF WATER QUALITY

> PARAMETRS OF WATER QUALITY

2. QUALITY OF DRINKING WATER

The development and the setting of regulations and standards for drinking water quality in different countries since the late 19thand early 20th centuries have changed from simply regulating the macro components of natural water to more insightful knowledge about the impact of anthropogenic contaminants and toxic micro components of water on human organisms[39].

In connection with the worsening of the ecological state of surface and underground sources, the issue of water quality control, used by people for drinking purposes, became more acute. As a result of the low quality of drinking water, real threats to the sanitary epidemiological situation in various regions of the planet crop out.

An increase of the quality of the matter being controlled in national standards of various countries of the world does not solve the issue of obtaining safe drinking water at centralized water-treatment stations either. All this calls expensive equipment and the complication of technological processes. Special attention should be paid to the fact that over the last two to three decades, an uncontrolled sharp increase of chemical compounds in the environment took place. In addition, drinking water obtained from surface sources is unsafe due to the presence micro toxins in it. Toxic micromycetes in surface waters and distribution systems. These micromycetes are not disinfected by current techniques used at centralized water treatment stations, even when chlorinated with high doses.

The first countries in the world that developed state standards for drinking water quality were the USA and the USSR. Owing to a high level of bacterial pollution of surface waters, drinking waters were disinfected with chlorine. This was one of the greatest mistakes of mankind. Since water always contains organic compounds, its chlorination inevitably results in the formation of very toxic, mutagenic, and carcinogenic organochlorine compounds. For the first time in the history of mankind, people began to drink chlorinated water hazardous for human health—technogenic water! As a result, there was an increase in the concentration of organochlorine compounds in drinking water.

Given such a dangerous factor, more sophisticated technologies of water treatment began to be developed. These technologies include preliminary filtration from suspended particles, primary chlorination, and chemical water treatment by coagulation concurrent with aluminum, iron, and flocculants of organic and inorganic origin, then filtration on sand and carbon filters. For suppressing the development of microorganisms in pipelines, the water again is treated with chlorine of such a concentration that at the outlet of the faucet of every consumer the content of residual activated chlorine is within the range of 0.3–0.5mg/dm^3.

39 M. J. Figueras and J. J. Borrego, "New perspectives in monitoring drinking water microbial quality," International Journal of Environmental Research and Public Health, vol. 7, pp.4179–4202, 2010

Schematic chlorine dioxide, possessing a higher oxidizing potential, is used instead of chlorine in a number of countries, according to regulations. Potentials of some oxidants are shown in the Table below.

Chemical substance and its formula		Oxidizing potential, eV
Chlorine	Cl_2	1.36
Chlorine dioxide	ClO_2	1.57
Hydrogen peroxide	H_2O_2	1.78
Ozone	O_3	2.07
Atomic oxygen	O	2.42
Hydroxyl radical	$HO^{\bullet}$	2.80

Table 9:Potentials of some oxidants

V. Goncharuk, A.V. Dumansky Institute of Colloid Chemistry and Chemistry ofWater, National Academy of Sciences, 42 Academician Vernadskoho Boulevard, Kyiv 03680, Ukraine, 29 August 2013

Advantages of the current technology include the fact that the decontamination process occurs more effectively. However, it also means that chlorine dioxide may produce a broader set of organochlorine compounds.

An especially negative side of the above mentioned technologies is the use of coagulants containing aluminum. It introduces a new, very dangerous contamination of drinking water with residual aluminum compounds. It was known for a long time that aluminum ions contained in drinking water are exceptionally toxic and affect human health. Several publications deal with this research. This is why the World Health Organization from year to year toughens the requirements regarding the concentration of residual aluminum in drinking water.

Water treatment facilities built in compliance with the effective world standards already are not capable of preventing the ingress of substances to drinking water. In this regard, their joint effect became a real threat to human health[40].

In the last century, for the first time, Russian scientists proposed a fundamentally new approach in water treatment technology—the use of ozone instead of chlorine. The world first ozonizer was developed in Lomonosov Moscow State University, and the first ozonation station for water treatment was built and commissioned in St. Petersburg before World War I. then, many years passed before the world community started to treat this technology with due attention.

Currently, the quality of water is commonly defined by some chemical-physical parameters that characterize water based mainly on the presence or absence of certain substances (ions, salts, molecules, microorganisms, suspended solids, etc.).

40 S.-L. Loo, A. G. Fane, W. B. Krantz, and T. Lim, "Emergency water supply: a review of potential technologies and selection criteria," Water Research, vol. 46, no. 10, pp. 3125–3151, 2012

2.1 VALUTATION OF WATER QUALITY

Till today, there is not a recognized method for measuring and evaluating the overall qualitative capacity of water to supporting life. Recent discoveries on the structure and behavior of water show that the quality of water is something more than the simple synthesis of its content.

In fact, an energetic-informational content emerges that is relevant for the biological functions of our organism and beyond.

It therefore seems natural to ask ourselves how it is possible to evaluate the "vitality" characteristics of water and therefore, how it is possible to integrate the current standards for assessing water quality with methods of measuring its energy characteristics. According to the Research Group of the Healing Water Institute (Emerson College, UK) the quality of water is difficult to define and does not depend solely on its chemical composition.

In particular, on the one hand there is the relationship of water with its ecological context and its ability to sustain life and on the other hand its purity. Unwanted chemical and biological constituents create pollution, while on the other hand, the lack of some trace elements reduces the quality of water life support.

The most popular definition of water quality is "it is the **physical**, **chemical**, and **biological** characteristics of water"[41] [42]

2.2 PARAMETRS OF WATER QUALITY

2.2.1 Physical parameters of water quality

Turbidity: Turbidity is the cloudiness of water. It is a measure of the ability of light to pass through water. It is caused by suspended material such as clay, silt, organic material, plankton, and other particulate materials in water.

Turbidity is measured by an instrument called nephelometric turbidimeter, which expresses turbidity in terms of NTU or TU. A TU is equivalent to 1 mg/L of silica in suspension[43]. Turbidity more than 5 NTU can be visible to the average person while turbidity in muddy water, it exceeds 100 NTU. Groundwater normally has very low turbidity because of the natural filtration that occurs as the water penetrates through the soil[44].

Temperature: Palatability, viscosity, solubility, odors, and chemical reactions are influenced by temperature. Thereby, the sedimentation and chlorination processes and biological oxygen demand (BOD) are temperature dependent [45]. It also affects the biosorption process of thedissolved

41 Spellman FR. Handbook of Water and Wastewater Treatment Plant Operations. 3rd ed. Boca Raton: CRC Press; 2013
42 Alley ER. Water Quality Control Handbook. Vol. 2. New York: McGraw-Hill; 2007
43 APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Association; 2005
44 Spellman FR. The Drinking Water Handbook. 3rd ed. Boca Raton: CRC Press; 2017
45 Davis ML. Water and Wastewater Engineering—Design Principles and Practice. New York: McGraw-Hill; 2010

heavy metals in water[46].

Color: Color is graded on scale of 0 (clear) to 70 color units. Pure water is colorless, which is equivalent to 0 color units.

Color is measured by comparing the water sample with standard color solutions or colored glass disks. One color unit is equivalent to the color produced by a 1 mg/L solution of platinum (potassium chloroplatinate (K2PtCl6))[47].

The color of a water sample can be reported as follows:

- Apparent color is the entire water sample color and consists of both dissolved and suspended components color
- True color is measured after filtering the water sample to remove all suspended material[48]

Taste and odor: Taste and odor in water can be caused by foreign matter such as organic materials, inorganic compounds, or dissolved gasses. These materials may come from natural, domestic, or agricultural sources[49].

Solids: Solids occur in water either in solution or in suspension, These two types of solids can be identified by using a glass fiber filter that the water sample passes through[50]. By definition, the suspended solids are retained on the top of the filter and the dissolved solids pass through the filter with the water.

If the filtered portion of the water sample is placed in a small dish and then evaporated, the solids as a residue. This material is usually called total dissolved solids or TDS.

Total solid(TS)=Total dissolved solid(TDS)+Total suspended solid(TSS)

Water can be classified by the amount of TDS per liter as follows:

- freshwater: <1500 mg/L TDS;
- brackish water: 1500–5000 mg/L TDS;
- saline water: >5000 mg/L TDS.

The residue of TSS and TDS after heating to dryness for a defined period of time and at a specific temperature is defined as fixed solids. Volatile solids are those solids lost on ignition (heating to 550°C).

46 Abbas SH, Ismail IM, Mostafa TM, Sulaymon AH. Biosorption of heavy metals: A review. Journal of Chemical Science and Technology. 2014;3:74-102
47 APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Association; 2005
48 Tchobanoglous G, Peavy HS, Rowe DR. Environmental Engineering. New York: McGraw-Hill Interamericana; 1985
49 DeZuane J. Handbook of Drinking Water Quality. 2nd ed. New York: John Wiley & Sons; 1997
50 Tchobanoglous G, Burton FL, Stensel HD. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. 4th ed. New Delhi: Tata McGraw-Hill Limited; 2003

Electrical conductivity (EC): The electrical conductivity (EC) of water is a measure of the ability of a solution to carry or conduct an electrical current[51]. Since the electrical current is carried by ions in solution, the conductivity increases as the concentration of ions increases. Therefore, it is one of the main parameters used to determine the suitability of water for irrigation and firefighting.

Units of its measurement are as follows:

U.S. units = micromhos/cm and S.I. units = milliSiemens/m (mS/m) or dS/m (deciSiemens/m) where (mS/m) = 10 umho/cm (1000 µS/cm = 1 dS/m).

Pure water is not a good conductor of electricity. Typical conductivity of water is as follows:

- Ultra-pure water: 5.5 × 10−6 S/m;
- Drinking water: 0.005–0.05 S/m;
- Seawater: 5 S/m.

2.2.2 Chemical parameters of water quality

PH: pH is one of the most important parameters of water quality. It is defined as the negative logarithm of the hydrogen ion concentration[52]. pH of water is a measure of how acidic/basic water is Acidic water contains extra hydrogen ions (H+) and basic water contains extra hydroxyl (OH−) ions[53]

The effects of pH on other chemicals in water can be summarized as follows:

- Heavy metals such as cadmium, lead, and chromium dissolve more easily in highly acidic water (lower pH). This is important because many heavy metals become much more toxic when dissolved in water[54].
- A change in the pH can change the forms of some chemicals in the water. Therefore, it may affect aquatic plants and animals. For instance, ammonia is relatively harmless to fish in neutral or acidic water. However, as the water becomes more alkaline (the pH increases), ammonia becomes progressively more poisonous to these same organisms.

Acidity: The acidity of water is its quantitative capacity to neutralize a strong base to a selected pH level. Acidity in water is usually due to carbon dioxide, mineral acids, and hydrolyzed salts such as ferric and aluminum sulfates. Acids can influence many processes such as corrosion, chemical reactions and biological activities[55].

Carbon dioxide from the atmosphere or from the respiration of aquatic organisms causes acidity

51 Tchobanoglous G, Burton FL, Stensel HD. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. 4th ed. New Delhi: Tata McGraw-Hill Limited; 2003
52 Spellman FR. The Drinking Water Handbook. 3rd ed. Boca Raton: CRC Press; 2017
53 Alley ER. Water Quality Control Handbook. Vol. 2. New York: McGraw-Hill; 2007
54 DeZuane J. Handbook of Drinking Water Quality. 2nd ed. New York: John Wiley & Sons; 1997
55 APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Association; 2005

when dissolved in water by forming carbonic acid (H2CO3). The level of acidity is determined by titration with standard sodium hydroxide (0.02 N) using phenolphthalein as an indicator[56].

Alkalinity: The alkalinity of water is its acid-neutralizing capacity comprised of the total of all titratable bases. The measurement of alkalinity of water is necessary to determine the amount of lime and soda needed for water softening (e.g., for corrosion control in conditioning the boiler feed water)57. Alkalinity of water is mainly caused by the presence of hydroxide ions (OH−), bicarbonate ions (HCO3−), and carbonate ions (CO32−), or a mixture of two of these ions in water. As stated in the following equation, the possibility of OH− and HCO3− ions together are not possible because they react together to produce CO32− ions:

$$OH^- + HCO_3^- \rightarrow CO_3^{2-} + H_2O$$

Alkalinity is determined by titration with a standard acid solution (H2SO4 of 0.02 N) using selective indicators (methyl orange or phenolphthalein).

The high levels of either acidity or alkalinity in water may be an indication of industrial or chemical pollution. Alkalinity or acidity can also occur from natural sources such as volcanoes. The acidity and alkalinity in natural waters provide a buffering action that protects fish and other aquatic organisms from sudden changes in pH. For instance, if an acidic chemical has somehow contaminated a lake that had natural alkalinity, a neutralization reaction occurs between the acid and alkaline substances; the pH of the lake water remains unchanged. For the protection of aquatic life, the buffering capacity should be at least 20 mg/L as calcium carbonate.

Chloride: Chloride occurs naturally in groundwater, streams, and lakes, but the presence of relatively high chloride concentration in freshwater (about 250 mg/L or more) may indicate wastewater pollution[58]. Chlorides may enter surface water from several sources including chloride-containing rock, agricultural runoff, and wastewater.

Chloride ions Cl− in drinking water do not cause any harmful effects on public health, but high concentrations can cause an unpleasant salty taste for most people. Chlorides are not usually harmful to people; however, the sodium part of table salt has been connected to kidney and heart diseases[59]. Small amounts of chlorides are essential for ordinary cell functions in animal and plant life.

Chlorine residual: Chlorine (Cl2) does not occur naturally in water but is added to water and wastewater for disinfection. While chlorine itself is a toxic gas, in dilute aqueous solution, it is not harmful to human health. In drinking water, a residual of about 0.2 mg/L is optimal. The residual concentration which is maintained in the water distribution system ensures good sanitary quality of water[60].

56 Tomar M. Quality Assessment of Water and Wastewater. Boca Raton: CRC Press; 1999
57 Tchobanoglous G, Burton FL, Stensel HD. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. 4th ed. New Delhi: Tata McGraw-Hill Limited; 2003
58 Chatterjee A. Water Supply Waste Disposal and Environmental Pollution Engineering (Including Odour, Noise and Air Pollution and its Control). 7th ed. Delhi: Khanna Publishers; 2001
59 World Health Organization. Guidelines for Drinking-Water Q, Vol. 2, Health criteria and other supporting information. 1996
60 Davis ML. Water and Wastewater Engineering—Design Principles and Practice. New York: McGraw-Hill; 2010

Chlorine residual is normally measured by a color comparator test kit or spectrophotometer.

Sulfate: Sulfate ions (SO42−) occur in natural water and in wastewater. The high concentration of sulfate in natural water is usually caused by leaching of natural deposits of sodium sulfate (Glauber's salt) or magnesium sulfate (Epson salt). If high concentrations are consumed in drinking water, there may be objectionable tastes or unwanted laxative effects[61].

Nitrogen: There are four forms of nitrogen in water and wastewater: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. If water is contaminated with sewage, most of the nitrogen is in the forms of organic and ammonia, which are transformed by microbes to form nitrites and nitrates. Nitrogen in the nitrate form is a basic nutrient to the growth of plants and can be a growth-limiting nutrient factor[62].

A high concentration of nitrate in surface water can stimulate the rapid growth of the algae which degrades the water quality. Nitrates can enter the groundwater from chemical fertilizers used in the agricultural areas. Excessive nitrate concentration (more than 10 mg/L) in drinking water causes an immediate and severe health threat to infants. The nitrate ions react with blood hemoglobin, thereby reducing the blood's ability to hold oxygen which leads to a disease called blue baby or methemoglobinemia[63].

Fluoride: A moderate amount of fluoride ions (F−) in drinking water contributes to good dental health. About 1.0 mg/L is effective in preventing tooth decay, particularly in children.

Excessive amounts of fluoride cause discolored teeth, a condition known as dental fluorosis. In the warmer regions of the country, the maximum allowable concentration of fluoride for potable water is 1.4 mg/L; in colder climates, up to 2.4 mg/L is allowed.

Iron and manganese: Although iron (Fe) and manganese (Mn) do not cause health problems, they impart a noticeable bitter taste to drinking water even at very low concentration. These metals usually occur in groundwater in solution as ferrous (Fe2+) and manganous (Mn2+) ions. When these ions are exposed to air, they form the insoluble ferric (Fe3+) and manganic (Mn3+) forms making the water turbid and unacceptable to most people.

Copper and zinc: Copper (Cu) and zinc (Zn) are nontoxic if found in small concentrations. Actually, they are both essential and beneficial for human health and growth of plants and animals[64]. They can cause undesirable tastes in drinking water. At high concentrations, zinc imparts a milky appearance to the water. They are measured by the same methods used for iron and manganese measurements.

Hardness: Hardness is a term used to express the properties of highly mineralized waters. The

61 Davis ML, David A. Introduction to Environmental Engineering. 4th ed. New York: McGraw-Hill Companies; 2008
62 APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Association; 2005
63 Tchobanoglous G, Peavy HS, Rowe DR. Environmental Engineering. New York: McGraw-Hill Interamericana; 1985
64 World Health Organization. Guidelines for Drinking-Water Q, Vol. 2, Health criteria and other supporting information. 1996

dissolved minerals in water cause problems such as scale deposits in hot water pipes and difficulty in producing lather with soap[65].

Calcium (Ca2+) and magnesium (Mg2+) ions cause the greatest portion of hardness in naturally occurring waters. They enter water mainly from contact with soil and rock, particularly limestone deposits[66].

Water with more than 300 mg/L of hardness is generally considered to be hard, and more than 150 mg/L of hardness is noticed by most people, and water with less than 75 mg/L is considered to be soft.

From health viewpoint, hardness up to 500 mg/L is safe, but more than that may cause a laxative effect. Hardness is normally determined by titration with ethylene diamine tetra acidic acid or (EDTA) and Eriochrome Black and Blue indicators. It is usually expressed in terms of mg/L of Ca-CO3[67].

Total hardnessmg/LasCaCO3= calcium hardness mg/L as CaCO3+ magnesium hardness mg/L as CaCO3

Dissolved oxygen: Dissolved oxygen (DO) is considered to be one of the most important parameters of water quality in streams, rivers, and lakes. It is a key test of water pollution. **The higher the concentration of dissolved oxygen, the better the water quality.** Oxygen is slightly soluble in water and very sensitive to temperature. For example, the saturation concentration at 20°C is about 9 mg/L and at 0°C is 14.6 mg/L.

The actual amount of dissolved oxygen varies depending on pressure, temperature, and salinity of the water.

Biochemical oxygen demand (BOD): Bacteria and other microorganisms use organic substances for food. As they metabolize organic material, they consume oxygen. The organics are broken down into simpler compounds, such as CO2 and H2O, and the microbes use the energy released for growth and reproduction.

When this process occurs in water, the oxygen consumed is the DO in the water. If oxygen is not continuously replaced by natural or artificial means in the water, the DO concentration will reduce as the microbes decompose the organic materials. This need for oxygen is called the biochemical oxygen demand (BOD). The more organic material there is in the water, the higher the BOD used by the microbes will be. BOD is used as a measure of the power of sewage; strong sewage has a high BOD and weak sewage has low BOD[68].

65 Davis ML. Water and Wastewater Engineering—Design Principles and Practice. New York: McGraw-Hill; 2010
66 McGhee TJ, Steel EW. Water Supply and Sewerage. New York: McGraw-Hill; 1991
67 Tchobanoglous G, Peavy HS, Rowe DR. Environmental Engineering. New York: McGraw-Hill Interamericana; 1985
68 Tchobanoglous G, Burton FL, Stensel HD. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. 4th ed. New Delhi: Tata McGraw-Hill Limited; 2003

Chemical oxygen demand (COD): The chemical oxygen demand (COD) is a parameter that measures all organics: the biodegradable and the non-biodegradable substances. It is a chemical test using strong oxidizing chemicals (potassium dichromate), sulfuric acid, and heat, and the result can be available in just 2 h. COD values are always higher than BOD values for the same sample.

Toxic inorganic substances: A wide variety of inorganic toxic substances may be found in water in very small or trace amounts. Even in trace amounts, they can be a danger to public health. Some toxic substances occur from natural sources but many others occur due to industrial activities and/or improper management of hazardous waste[69].

Toxic organic substances: There are more than 100 compounds in water that have been listed in the literature as toxic organic compounds. They will not be found naturally in water; they are usually man-made pollutants. These compounds include insecticides, pesticides, solvents, detergents, and disinfectants. They are measured by highly sophisticated instrumental methods, namely, gas chromatographic (GC), high-performance liquid chromatographic (HPLC), and mass spectrophotometric[70].

Radioactive substances: Potential sources of radioactive substances in water include wastes from nuclear power plants, industries, or medical research using radioactive chemicals and mining of uranium ores or other radioactive materials. When radioactive substances decay, they release beta, alpha, and gamma radiation. Exposure of humans and other living things to radiation can cause genetic and somatic damage to the living tissues[71].

The unit of radioactivity used in water quality applications is the picocurie per liter (pCi/L); 1 pCi is equivalent to about two atoms disintegrating per minute[72].

2.2.3 Biological parameters of water quality

One of the most helpful indicators of water quality may be the presence or lack of living organisms. Biologists can survey fish and insect life of natural waters and assess the water quality on the basis of a computed species diversity index (SDI); hence, a water body with a large number of well-balanced species is regarded as a healthy system. Some organisms can be used as an indication for the existence of pollutants based on their known tolerance for a specified pollutant[73].

Bacteria: There are several distinctions among the various species of bacteria. One distinction depends on how they metabolize their food [38]. Bacteria that require oxygen for their metabolism are called aerobic bacteria, while those live only in an oxygen-free environment are called anaerobic bacteria. Some species called facultative bacteria can live in either the absence or the

69 Tchobanoglous G, Burton FL, Stensel HD. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. 4th ed. New Delhi: Tata McGraw-Hill Limited; 2003
70 APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Association; 2005
71 Skeppström K, Olofsson B. Uranium and radon in groundwater. European Water. 2007;17:51-62
72 Cothern CR. Radon, Radium, and Uranium in Drinking Water. Boca Raton: CRC Press; 2014
73 Abbas SH, Ismail IM, Mostafa TM, Sulaymon AH. Biosorption of heavy metals: A review. Journal of Chemical Science and Technology. 2014;3:74-102

presence of oxygen[74].

At low temperatures, bacteria grow and reproduce slowly. As the temperature increases, the rate of growth and reproduction doubles in every additional 10°C (up to the optimum temperature for the species). The majority of the species of bacteria having an optimal temperature of about 35°C[75].

A lot of dangerous waterborne diseases are caused by bacteria, namely, typhoid and paratyphoid fever, leptospirosis, tularemia, shigellosis, and cholera. Sometimes, the absence of good sanitary practices results in gastroenteritis outbreaks of one or more of those diseases[76].

Algae: Algae are microscopic plants, which contain photosynthetic pigments, such as chlorophyll. They are autotrophic organisms and support themselves by converting inorganic materials into organic matter by using energy from the sun, during this process they take in carbon dioxide and give off oxygen. Algae are primarily nuisance organisms in the water supply because of the taste and odor problems they create. Certain species of algae cause serious environmental and public health problems.

Viruses: Viruses are the smallest biological structures known to contain all genetic information necessary for their own reproduction. They can only be seen by a powerful electronic microscope. Viruses are parasites that need a host to live. They can pass through filters that do not permit the passage of bacteria. Waterborne viral pathogens are known to cause infectious hepatitis and poliomyelitis. Most of the waterborne viruses can be deactivated by the disinfection process conducted in the water treatment plant.

Protozoa: Protozoa are single-celled microscopic animal, consume solid organic particles, bacteria, and algae for food, and they are in turn ingested as food by higher level multicellular animals]. Aquatic protozoa are floating freely in water and sometimes called zooplankton. They form cysts that are difficult to inactivate by disinfection.

74 Nathanson JA. Basic Environmental Technology: Water Supply. New Delhi: Printice-Hall of India; 2004
75 Mara D, Horan NJ. Handbook of Water and Wastewater Microbiology. London: Elsevier; 2003
76 Tchobanoglous G, Peavy HS, Rowe DR. Environmental Engineering. New York: McGraw-Hill Interamericana; 1985

3 WATER TREATMENTS

3. WATER TREATMENTS

The general objectives for operators treating produced waterare: de-oiling (removal of dispersed oil and grease), desalination, removal of suspended particles and sand, removal ofsoluble organics, removal of dissolved gases, removal of naturally occurring radioactive materials (NORM), disinfection andsoftening (to remove excess water hardness)[77]. To meet upwith these objectives, operators have applied many standaloneand combined physical, biological and chemical treatmentprocesses for produced water management. Some of these technologies are reviewed in this section.

3.1 THERMAL TECNOLOGIES

The chemical process of changing saline water into potable or fresh water using different forms of energy is called desalination. Saline water is classified as either brackish water or seawater depending on the salinity and water source. Desalination produces two streams freshwater and a more concentrated stream (brine)[78].

Desalination methods were first used in boats or submarines which couldn't take water when they went on the oceans and looked for a method to produce their own drinkable water. But desalination plant have been early built, mainly in regions of the world were water is becoming more and more rare[79].

The two main commercial desalination technologies are those based on thermal and membrane processes.

3.1.1 THERMAL DESALINATION

Thermal distillation technologies are widely used in the Middle East, primarily because the region's petroleum reserves keep energy costs low. Thermal processes, except freezing, mimic the natural process of producing rain. Saline water is heated, producing water vapor that in turn condenses to form distilled water. These processes include multi stage flash (MSF), multiple-effect distillation (MED), vapor compression (VC) and low temperature evaporation (LTE). In all these processes, condensing steam is used to supply the heat needed to evaporate the water. Owing to their high-energy requirements, thermal processes are normally used for seawater desalination. Thermal processes are capable of producing high purity water and suited for industrial process applications. Thermal processes account for 55% of the total production and their unit capacities are higher compared to membrane processes[80].

77 Daniel Arthur J, Langhus BG, Patel C. Technical Summary of Oil & Gas, Produced Water Treatment Technologies. NETL, 2005.
78 Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010
79 http://waterprojectlondon.over-blog.com/article-ii-2-desalinisation-59096927.html
80 Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010

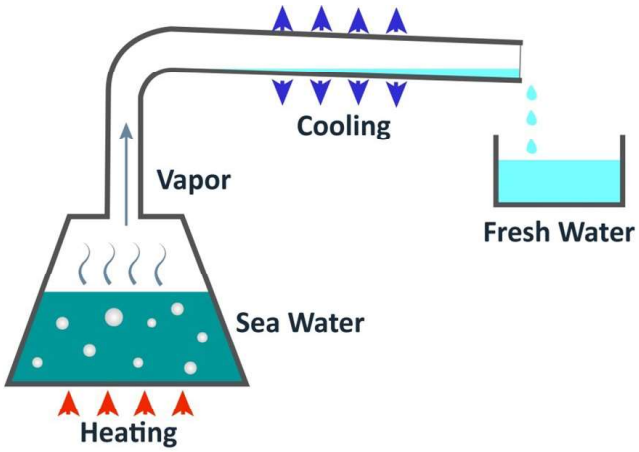


Figure 10: Thermal desalination principle,
http://a136.idata.over-blog.com

3.1.2 MULTI STAGE FLASH (MSF) PROCESS

Multi-stage flash distillation plants produce about 60% of all desalinated water in the world. The basic principle involved in the MSF process is to heat the sea water to about 90– 120°C using the heat of condensation of the vapor produced and supplementing with external steam. The heated sea water is subsequently flashed in successive stages maintained at decreasing levels of pressure. The vapor produced is condensed and recovered as pure water. MSF can accept higher contaminant loading (suspended solids, heavy metals, oil, grease, COD, BOD etc.) in feed sea water. It is capable of producing distilled quality product water good for power plants, process industries and several other high purity applications[81].

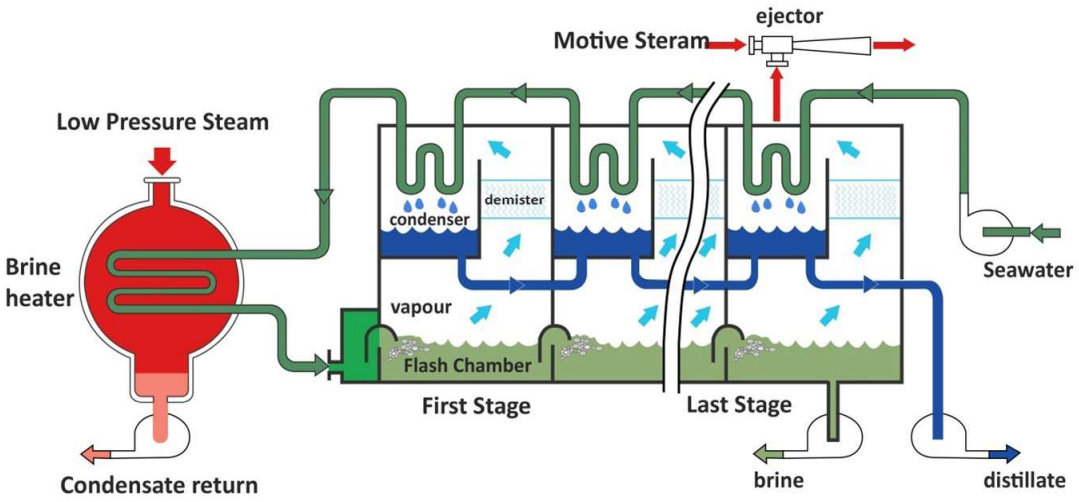


Figure 11: Schematic Diagram of Multi-Stage Flash (MSF) Process
http://www.wikiwater.fr/e-25-possibilities-of-using-sea.html

81 Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010

3.1.3 MULTI EFFECT DISTILLATION (MED)

MED process involves application of sufficient energy that convertssaline water to steam, which is condensed and recovered as pure water. Multiple effects are employed in order to improve the efficiency and minimize energy consumption. A major advantage of this system is the energy efficiency gained through the combination of several evaporator systems. Product water recovery from MED systems are in the range of 20 –67% depending on the type of the evaporator design employed[82].

MED plant has two or more effects. Each effect operates at a successively lower temperature and pressure. The first effect is heated by low pressure steam (about 0.3 bars). Vapors are generated from the feed sea water in the first effect and directed to the second effect. Thus vapors from the previous effect serve as the heat source to the succeeding effect for evaporating the brine. Vapor from the last effect is condensed in the final condenser where sea water is used as the coolant. The vapor produced in each effect is passed through the demisters to next effect. It is condensed inside the tubes transferring the latent heat to the brine falling outside the tube enabling a portion of the brine to evaporate. Low temperature MED unit operates at about 65°C and therefore allows the use of cheaper materials of construction due to less scaling and corrosion problems. MED is capable of producing pure distilled water similar to MSF. The possibility of low temperature operation, low grade heat and waste heat utilization, low cooling water requirement and low energy consumption have made MED an attractive alternative in recent years for sea water desalination[83].

Efficiency of MED plant can be improved by adding a vapor compressor. Mechanical Vapor Compressor (MVC) or Thermal Vapor Compressor (TVC) is used for this purpose depending on site specific conditions.

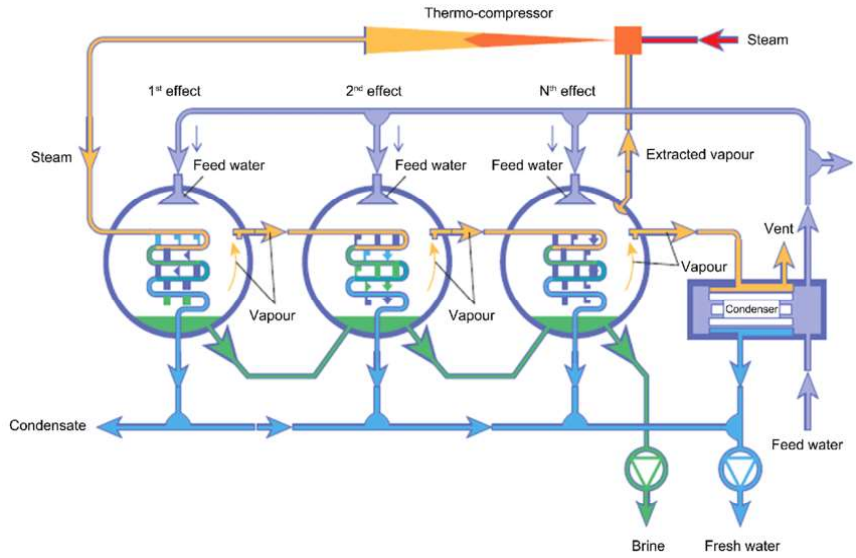


Figure 12: Multi-Effect Distillation Process (MED)
World Bank (2019) The Role of Desalination in an Increasingly Water-Scarce World. Washington DC.

82 U.S. Bureau of Reclamation. Desalting Handbook for Planners, 3rd edn. Desalination and Water Purification Research and Development, Program Report No. 72, 2003, 50 –73. http://www.usbr.gov/pmts/water/publications/reportpdfs/report072.pdf
83 Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010

3.1.4 LOW TEMPERATURE EVAPORATION (LTE)

LTE is one of the eco-friendly ways to produce desalinated water as it does not require chemical pretreatment of feed seawater.it is an attractive option as energy input for seawater desalination. Ocean thermal energy can also be utilized for sea water desalination. As the energy cost component is a major fraction of the desalinated water cost, utilization of waste heat.

The desalination unit essentially consists of three portions i.e. heater, separator and condenser. In the heater shell, vertical tubes are used. Feed sea water enters the unit at the bottom of the tubes and partly evaporates by the time it comes out from the top. After water and vapor mixture come out of the tubes, the vapor rises through the vertical shell, enters the horizontal tube bundle kept at the top of the vertical shell and condenses around the tubes (which are cooled by sea water flowing inside) producing desalinated water. The product water is pumped out[84].

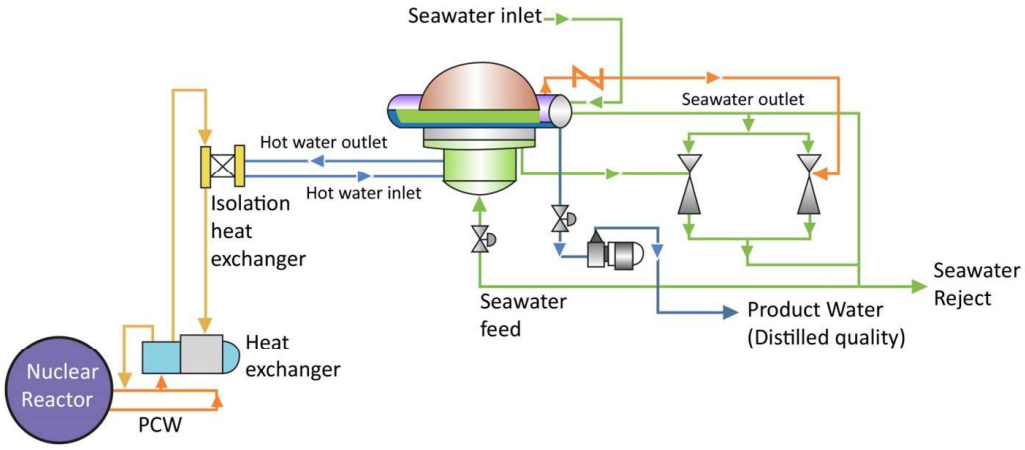


Figure 13: LTE Desalination using waste Heat
Environmental Impact Assessment of Nuclear Desalination, International Atomic Energy Agency, VIENNA, 2010

3.2 MEMBRANE FILTRATION THECNOLOGY

Membranes are microporous films with specific pore ratings, which selectively separate a fluid from its components. There are four established membrane separation processes, including microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO) and nanofiltration (NF)[85]. RO separates dissolved and ionic components, MF separates suspended particles, UF separates macromolecules[86] and NF is selective for multivalent ions[87]. MF and UF can be used as a standalone technology for treating industrial wastewater, but RO and NF are usually employed in water desalination. Membrane technology operates two types of filtration processes, cross-flow filtration or dead-end filtration, that can be a pressure (or vacuum)-driven system[88].

84 Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010
85 Xu P, Drewes JE. Viability of nanofiltration and ultra-low pressure reverse osmosis membranes for multi-beneficial use of methane produced water. Sep Purif Technol 2006;52:67 –76
86 Madaeni SS. The application of membrane technology for water disinfection. Water Res 1999;33:301 –8
87 Judd S, Jefferson B. Membranes for Industrial Wastewater Recovery and Re-use Oxford. Elsevier Ltd, 2003, 14 –169.
88 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.

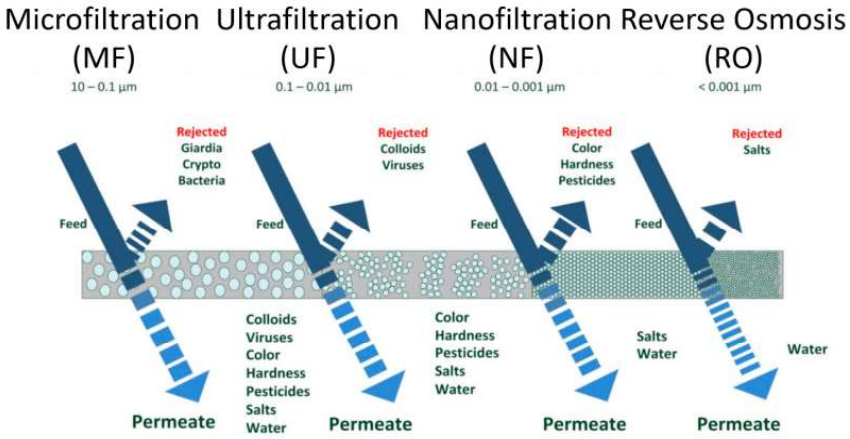


Figure 14: Classification of pressure driven membrane processes for water treatment technologies. Reprinted from
published by SDEWES Centre.

3.2.1 MICROFILTRATION/ ULTRAFILTRATION

MF has the largest pore size (0.1–3 mm) and is typically used for the removal of suspended solids and turbidity reduction. It can operate in either cross-flow or dead-end filtration. UF pore sizes are between 0.01 and 0.1 mm. They are employed in the removal of colour, odour, viruses and colloidal organic matter. UF is the most effective method for oil removal from produced water in comparison with traditional separation methods[89], and it is more efficient than MF for the removal of hydrocarbons, suspended solids and dissolved constituents from oilfield produced water. Both MF and UF operate at low transmembrane pressure (1–30 psi) and can serve as a pre-treatment to desalination but cannot remove salt from water[90].

3.2.2 POLYMERIC/CERAMIC MEMBRANES

Polymeric and ceramic membranes are used for UF/MF treatment of water. Polymeric MF/UF membranes are made from polyacrylonitrile and polyvinylidene and ceramic membranes from clays of nitrides, carbides and oxides of metals[91]. Ceramic UF/MF membranes have been used in a full-scale facility for the treatment of produced water. Product water from this treatment was reported to be free of suspended solids and nearly all non-dissolved organic carbon[92]. Ceramic UF/MF membranes can operate in both cross-flow filtration and dead-end filtration modes and have a lifespan of 10 years. Chemicals are not required for this process except during periodic cleaning of membranes and pre-coagulation (used to enhance contaminants removal).

89 He Y, Jiang ZW. Technology review: treating oilfield wastewater. Filtr Sep, 2008;45:14 –6.
90 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.
91 Khemakhem S, Larbot A, Ben Amar R. New ceramic microfiltration membranes from Tunisian natural materials: application for the cuttlefish effluents treatment. Ceram Int 2009;35:55–61.
92 Faibish RS, Cohen Y. Fouling-resistant ceramic-supported polymer membranes for ultrafiltration of oil-in-water microemulsions. J Membr Sci 2001;185:129–43.

3.2.3 REVERSE OSMOSIS AND NANOFILTRATION

Many decades ago, scientists noted that water molecules would spontaneously migrate through certain membranes that were separating a dilute solution from a concentrated solution. This phenomenon is called osmosis. They also noted that if pressure was added to the higher contaminant solution, this natural flow could be reversed. This reversal allows the contaminant solution to be concentrated further and allows purified water to be produced.

Where only a small volume of treated water is needed, approximately 0-10 gallons per day (gpd), RO is typically the most flexible and cost efficient treatment process available for private home use.

Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane to remove larger particles from drinking water. This membrane technology is not considered a proper filtration method. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property that is driven by chemical potential, a thermodynamic parameter. Reverse osmosis can remove many types of molecules and ions from solutions, including bacteria. Devices treating small volumes of water are often called “under-the-sink” or “point-of-use” (POU) sized treatment devices. Treatment devices which purify all water used in a home are commonly called “whole house” or “point-of-entry” sized water treatment devices[93].

RO is used for both brackish water and seawater desalination as well as for waste water treatment and water recovery/reuse. A typical RO desalting plant consists of three sections, namely pretreatment section, membrane section and post treatment section. Conventional pretreatment section typically consists of particulate filtration, micron filtration and chemicals additions. Every R.O. system has at least one pre-filter (before the RO membrane) in the system- an activated carbon filter, which removes chlorine and other chemicals. This pre-filter helps to prevent fouling of the RO membrane filter. On some RO systems, there are sometimes two pre-carbon filters. Membrane section consists of membrane elements housed in pressure vessels through which pretreated saline water is passed under pressure in excess of its osmotic pressure with the help of a high pressure pump coupled with energy recovery device. The post treatment section consists of lime treatment for pH correction and chlorination for disinfection as required to meet public health standards and to make the water noncorrosive to the water distribution systems. Energy consumption depends on the salt content of the feed water. Development of RO membranes of very high rejection, while maintaining high permeability, has potential to reduce the energy consumption. Development of better energy recovery devices can further reduce the energy consumption. As the success of RO desalination hinges on the proper pre-treatment of the feed water, various membranes could precede RO in order to selectively remove suspended solids (microfiltration), colloids/turbidity & organics (ultrafiltration) and hardness and sulphates (nanofiltration)[94].

The obvious disadvantage of reverse osmosis is the lack of selectivity of the membranes to remove

93 Hazen Drive, Reverse Osmosis Treatment for Drinking Water, New Hampshire, 2009
94 Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010

contaminants. This means that not only toxic impurities and microorganisms are removed, but also vital minerals and micro elements. Will this water fulfill physiological requirements? Of course not! After all, purity of drinking water is not the only criteria of water quality. Also important is the extent to which drinking water is the source of elements necessary for normal body functioning. Water obtained by the reverse osmosis method cannot be called drinking water; one gets somewhat distilled water.

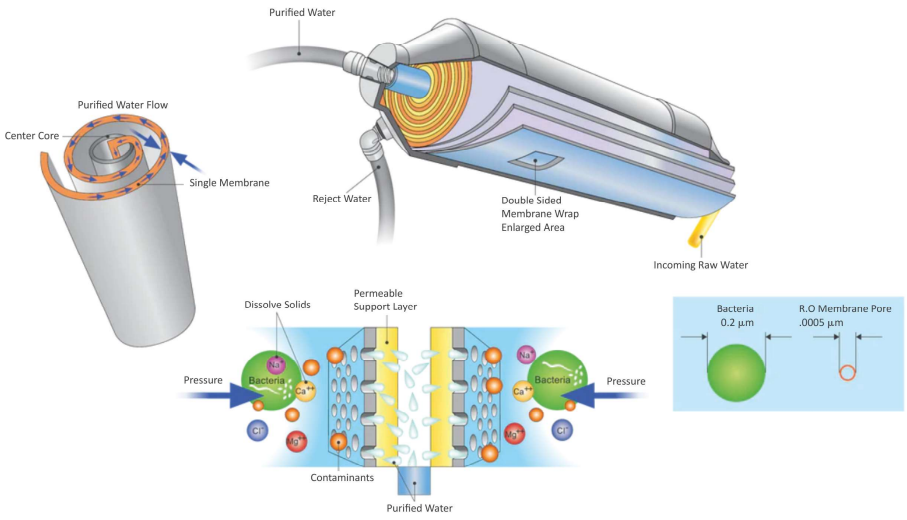


Figure 15: Reverse Osmosis membrane

Technology	Ceramic MF/UF membrane	Polymeric MF/UF membrane	NF	RO
Feasibility	Ceramic membranes have been used to treat oilfield produced water and extensively used in other industrial water treatments. They are applicable to all types of produced water irrespective of their TDS and salt concentrations, but produced water with high concentrations may be problematic	Applicable to water with high TDS and salt concentrations and also has the potential to treat produced water however it is extensively used in the municipal water treatment	This technology is used for water softening and removal of metals from wastewater. It is specifically efficient for feed water containing TDS ranging from 500 to 25 000 mg/l. NF is a poor technology for produced water treatment and is inappropriate as a standalone technology	This is a robust technology for seawater desalination and has been employed in produced water treatment. For this technology to be effective in produced water treatment, extensive pre-treatment of feed water is necessary. Several pilot studies failed due to poor pre-treatment and insufficient system integration
Energy consumption	Not available	Not available	It uses electrical energy and its energy requirement is less than what is required in RO systems. Approximately NF system requires 0.08 Kwh/bbl to power its high-pressure pumps	RO use electrical energy for its operation. SWRO requires 0.46–0.67 KWh/bbl if energy recovery device is integrated . BWRO require less energy than equivalent SWRO system. BWRO requires ~0.02–0.13 KWh/bbl of energy to power the system's pumps
Chemical use	Ferric chloride, polyaluminium chloride and aluminium sulphate are common coagulants used for pre-coagulation. Acids, bases and surfactants are used in cleaning process	Ferric chloride, polyaluminium chloride and aluminium sulphate are common coagulants used for pre-coagulation. Acids, bases and surfactants are used in cleaning process	Caustic and scale inhibitors are required to prevent fouling. NaOH, H_2O_2, Na_2SO_4, HCl, or Na_4EDTA are required for cleaning the system.	Caustic and scale inhibitors are required to prevent fouling. NaOH, H_2O_2, Na_2SO_4, H_3PO_4, HCl, or Na_4EDTA are required for cleaning the system
Pre/ post-treatment	Cartridge filtration and coagulation are usually used as a pre-treatment. Post-treatment may be required for polishing depending on the product water	Cartridge filtration and coagulation are usually used as a pre-treatment. Post-treatment may be required for polishing depending on the product water	Extensive pre-treatment is required to prevent fouling of membrane. Product water may require remineralization to restore SAR values	Extensive pre-treatment is required to prevent fouling of membrane. Product water may require remineralization or pH stabilization to restore SAR values
Overall cost	Not available	Capital costs depend on feed water quality and size of the polymeric membrane system. Approximate capital cost is $0.02–$0.05/bpd. Approximate Operation and Maintenance costs $0.02–$0.05/bpd	Capital cost range from $35 to $170/bpd. Operating cost is ~$0.03/bbl.	Capital costs of BWRO vary from $35 to $170/bpd and operating costs are ~$0.03/bbl. Capital costs of SWRO vary from $125 to $295/bpd and operating costs are ~$0.08/bbl
Life cycle	>10 years	7 years or more	3–7 years	3–7 years
Advantages	(1) Product water is totally free of suspended solids (2) It can be operated in cross-flow or dead-end filtration mode (3) Product water recovery range from 90% to 100% (4) Ceramic membranes have a longer lifespan than polymeric membranes	(1) Product water is free of suspended solids (2) Product water recovery range from 85% to 100%	(1) It has high pH tolerance (2) System can be operated automatically leading to less demand of skilled workers (3) Energy costs can be reduced by implementing energy recovery subsystems (4) It does not require solid waste disposal (5) Water recovery between 75% and 90%	(1) It has high pH tolerance (2) System can be operated automatically leading to less demand of skilled workers (3) Energy costs can be reduced by implementing energy recovery subsystems (4) It performs excellently for produced water treatment with appropriate pre-treatment (5) It does not require concentrate treatment as brine generated is usually disposed into sea (6) Product water recovery in SWRO is between 30% and 60%, and between 60% and 85% in BWRO
Disadvantages	(1) Irreversible membrane fouling can occur with significant amount of iron concentration in feed water (2) Membrane requires periodic cleaning (3) Waste generated during backwash and cleaning processes require disposal/ recycling or further treatment	(1) Membrane requires periodic cleaning (2) Waste generated during backwash and cleaning processes require disposal/ recycling or further treatment	(1) It is highly sensitive to organic and inorganic constituents in the feed water (2) Membranes cannot withstand feed temperatures in excess of 45 °C (3) It requires several backwashing cycles	(1) It is highly sensitive to organic and inorganic constituents in the feed water (2) Membranes cannot withstand feed temperatures in excess of 45 °C

Table 10:Comparison of produced water membrane treatment technologies
International Journal of Low-Carbon Technologies 2014, 9, 157–177

3.3 BIOLOGICAL AERATED FILTERS

Biological aerated filter (BAF) is a class of biological technologies which consists of permeable media that uses aerobic conditions to facilitate biochemical oxidation and removal of organic constituents in polluted water. Media is not more than 4 in in diameter to prevent clogging of pore spaces when sloughing occur[95]. BAF can remove oil, ammonia, suspended solids, nitrogen, chemical oxygen demand (COD), biological oxygen demand (BOD), heavy metals, iron, soluble organics, trace organics and hydrogen sulphide from produced water. It is most effective for produced water with chloride levels below 6600 mg/l[96].

This process requires upstream and downstream sedimentation to allow the full bed of the filter to be used. Removal efficiencies of up to 70% nitrogen, 80% oil, 60% COD, 95% BOD and 85% suspended solids have been achieved with BAF treatment[97].

Water recovery from this process is nearly 100% since waste generated is removed in solid form. BAF usually have a long lifespan[98]. It does not require any chemicals or cleaning during normal operations. Its power requirement is 1 –4 kWh/day, and capital accounts for the biggest cost of this technology. Solids disposal is required for accumulated sludge in sedimentation basins and can account for up to 40% of the total cost of this technology.

3.4 HYDROCYCLONES

Hydrocyclones use physical method to separate solids from liquids based on the density of the solids to be separated. They are made from metals, plastics or ceramic, and usually have a cylindrical top and a conical base with no moving parts. The performance of the hydrocyclone is determined by the angle of its conical section. Hydrocyclones can remove particles in the range of 5–15 mm and have been widely used for the treatment of produced water[99].

Nearly 8 million barrels per day of produced water can be treated with hydrocyclones[100]. They are used in combination with other technologies as a pre-treatment process. They have a long lifespan and do not require chemical use or pre-treatment of feed water. A major disadvantage of this technology is the generation of large slurry of concentrated solid waste.

95 EPA. Onsite Wastewater Treatment and Disposal Systems Design Manual.US EPA, 1980.
96 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.
97 Su D, Wang J, Liu K, et al. Kinetic performance of oil-field produced water treatment by biological aerated filter. Chin J Chem Eng 2007;15:591–4.
98 Ball HL. Nitrogen reduction in an on-site trickling filter/upflow filters wastewater treatment system. In: Proceedings of the 7th International Symposium on Individual and Small Community Sewage Systems, ,American Society of Agricultural Engineers, 1994.
99 Jain Irrigation Systems Ltd. Sand separator—Jain hydro cyclone filter,2010.
100 Svarovsky L. Hydrocyclones: Analysis and Applications. Kluwer Academic Publishers, 1992, 1 –3.

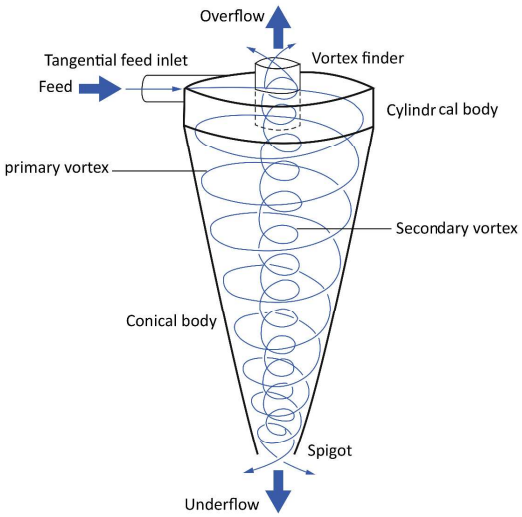


Figure 16: Hydrocyclone flow scheme
D. Vega-Garcia, P.R. Brito-Parada, J.J. Cilliers, Optimising small hydrocyclone design using 3D printing and CFD simulations, London SW7 2AZ, UK

3.5 GAS FLOTATION

Flotation technology is widely used for the treatment of conventional oilfield produced water. This process uses fine gas bubbles to separate suspended particles that are not easily separated by sedimentation. When gas is injected into produced water, suspended particulates and oil droplets are attached to the air bubbles as it rises. This results into the formation of foam on the surface of the water which is skimmed off as froth[101].

There are two types of gas flotation technology (dissolved gas flotation and induced gas flotation) based on the method of gas bubble generation and resultant bubble sizes. In dissolved gas floatation units, gas is introduced into the flotation chamber by a vacuum or by creating a pressure drop, but mechanical shear or propellers are used to create bubbles in induced gas flotation units[102]. Gas floatation can remove particles as small as 25 mm and can even remove contaminants up to 3 mm in size if coagulation is added as pre-treatment, but it cannot remove soluble oil constituents from water[103]. Flotation is most effective when gas bubbles size is less than oil droplet size and it is expected to work best at low temperature since it involves dissolving gas into water stream.

Flotation can be used to remove grease and oil, natural organic matter, volatile organics and small particles from produced water. It does not require chemical use, except coagulation chemicals are added to enhance removal of target contaminants. Solid disposal will be necessary for the sludge generated from this process.

101 Cassidy AL. Advances in flotation unit design for produced water treatment. In: SPE 25472 Production Operations Symposium, Oklahoma, 1993.
102 C¸ akmakce M, Kayaalp N, Koyuncu I. Desalination of produced water from oil production fields by membrane processes. Desalination 2008;222:176–86
103 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.

3.6 ADSORPTION

Adsorption is generally utilized as a polishing step in a treatment process rather than as a standalone technology since adsorbents can be easily overloaded with organics. It has been used to remove manganese, iron, total organic carbon (TOC), BTEX, oil and more than 80% of heavy metals present in produced water[104]. There are a variety of adsorbents, such as **activated carbon**, **organo-clays, activated alumina and zeolites**. Adsorption process is applicable to water treatment irrespective of salinity. It requires a vessel to contain the media and pumps to implement backwashes which happen periodically to remove particulates trapped in the voids of the media.

Replacement or regeneration of the media may be required depending on feed water quality and media type. The rate of media usage is one of the main operational costs of adsorption technology[105]. Chemicals are used to regenerate media when all active sites are blocked which often results in liquid waste disposal, and media replacement results in solid waste management.

3.7 ION EXCHANGE THECNOLOGY

Ion exchange is a widely applied technology in industrial operations for various purposes, including utilization for the treatment of CBM produced water. It is especially useful in the removal of monovalent and divalent ions and metals by resins from produced water[106]. Nadav suggested that ion exchange has the potential to remove boron from RO permeate of produced water. Ion exchange technology has a lifespan of 8 years and will require pre-treatment options for solid removal. It also requires the use of chemicals for resin regeneration and disinfection. The operating cost accounts for more than 70% of the overall cost of this technology.

3.8 CHEMICAL OXIDATION

Chemical oxidation is an established and reliable technology for the removal of colour, odour, COD, BOD, organics and some inorganic compounds from produced water. This kind of treatment depends on oxidation/reduction reactions occurring together in produced water because free electrons cannot exist in solution. Oxidants commonly used include ozone, peroxide, permanganate, oxygen and chlorine. The oxidant mixes with contaminants and causes them to break down. The oxidation rate of this technology depends on chemical dose, type of the oxidant used, raw water quality and contact time between oxidants and water. Chemical cost during this process may be high[107].

104 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.
105 Spellman FR. Handbook of Water and Wastewater Treatment Plant Operations. CRC Press, 2003, 3 –630.
106 Clifford DA. Ion exchange and inorganic adsorption. In Letterman RD(ed.). Water Quality and Treatment. McGraw-Hill, 1999.
107 AWWA. Water Treatment Plant Design, 3rd edn. McGraw-Hill, 1998, 221–80.

3.9 ELECTRODIALYSIS/ELECTRODIALYSIS REVERSAL

Electrodialysis (ED) and ED reversal (EDR) are mature electrochemically driven desalination technologies. These processes involve separation of dissolved ions from water through ion exchange membranes. They use a series of ion exchange membranes containing electrically charged functional sites arranged in an alternating mode between the anode and the cathode to remove charge substances from the feed water. If the membrane is positively charged, only anions are allowed to pass through it. Similarly, negatively charged membranes allow only cations to pass through them. EDR uses periodic reversal of polarity to optimize its operation[108].

EDR and ED technologies have only been tested on a laboratory scale for the treatment of produced water. Sirivedhin et al reported that ED is an excellent produced water treatment technology, but it works best for treating relatively low saline produced water. ED/EDR membrane lifetime is between 4 and 5 years, but major limitations of this technology are regular membrane fouling and high treatment cost.

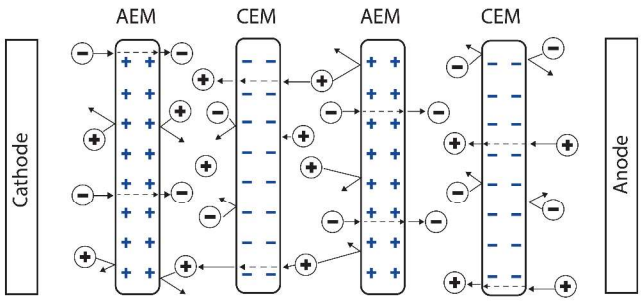


Figure 17: . A typical electrodialysis system with cation exchange membranes (CEMs) and anion

K.Barros, T.Scarazzato, V.Pérez-Herranz ,D.Crocce Romano, Treatment of Cyanide-Free Wastewater from Brass.., University of São Paulo (USP), 11 April 2020

3.10 Freeze thaw evaporation

Freeze thaw evaporation (FTE) process developed in 1992 by Energy & Environmental Research Centre (EERC) and B.C. Technologies Ltd (BCT) is a mature and robust technology for produced water treatment and disposal[109]. FTE process employs freezing, thawing and conventional evaporation for produced water management. Naturally, salts and other dissolved constituents in produced water lower its freezing point below 32 F. When produced water is cooled below 32 F but not below its freezing point, relatively pure ice crystals and an unfrozen solution are formed. The unfrozen solution contains high concentration of dissolved constituents in the produced water and it is drained from the ice. The ice can be collected and melted to obtain clean water. About 50% of water can be recovered from this process during winter, but at other seasons, no water is recovered because FTE works as a conventional evaporation pond. FTE can remove over 90% of heavy metals, TDS, volatile and semi-volatile organics, total suspended solids and total recoverable petroleum hydrocarbons in produced water[110].

108 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.

109 Energy & Environment Research Center. Free-Thaw. 2010. Retrieved 10 June 2011. http://www.undeerc.org/centersofexcellence/waterfreeze.aspx.

110 Boysen JE, Harju JA, Shaw B, et al. The current status of commercial deployment of the freeze thaw evaporation treatment of produced water. In: SPE/EPA Exploration and Production Environmental Conference. Austin, TX, SPE 52700, 1999, 1–3.

FTE does not require chemicals, infrastructure or supplies that limit its use. It is easy to operate and monitor, and has a life expectancy of 20 years[111]. However, it can only work in a climate that has substantial number of days with temperatures below freezing and usually requires a significant amount of land. Waste disposal is essential when using FTE technology because it generates a significant amount of concentrated brine and oil.

3.11 Dewvaporation: AltelaRain^{SM} process

Its principle of operation is based on counter current heat exchange to produce distilled water. Feed water is evaporated in one chamber and condenses on the opposite chamber of a heat transfer wall as distilled water Approximately 100 bbl/day of produced water with salt concentration in excess of 60 000 mg/l TDS can be processed by this system. High removal rates of heavy metals, organics and radionuclides from produced water have also been reported for this technology. In one plant, chloride concentration was reduced from 25 300 to 59 mg/l, TDS from 41 700 to 106 mg/l and benzene concentration from 450 mg/l to nondetectable after treatment with AlterRain^{SM}[112].

According to Altela Inc., energy requirements of this system are low because it operates at ambient pressures and low temperatures. This makes it a viable alternative water treatment at remote oil wells where there is no high power grid, but there is no information on the overall cost of the system which is likely to be its major disadvantage.

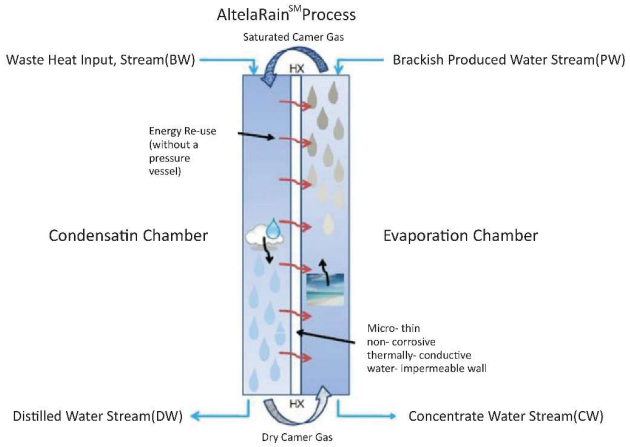


Figure 18: Schematic diagram of AltelaRain SM process
International Journal of Low-Carbon Technologies 2014, 9, 157–177

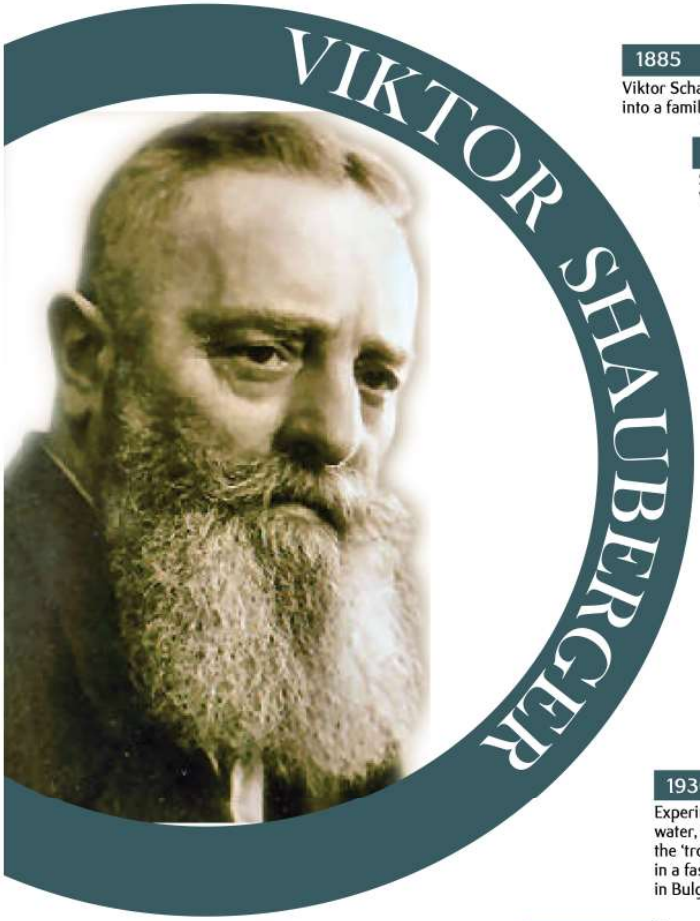
111 Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009, 8–128.
112 Godshall NA. AltelaRain℠ produced water treatment technology: making water from waste. In: International Petroleum Environmental Conference, ALTELA™, Houston, TX, 2006, 1 –9

4

VORTEX TECHNOLOGY

- WHO WAS VIKTOR SCHAUBERGER
- OXYGENATION
- APPLICATION OF SCHAUBERGER THEORIES
- STRUCTURED WATER

4. VORTEX TECHNOLOGY



1885
Viktor Schauberger born in Holzschlag, Upper Austria into a family with a long tradition of caring for the unspoilt Alpine forests

1914-18
Soon after the birth of his son Walter Viktor was enlisted in the Kaiser's army

1919
Appointed forest warden and gamekeeper

1920
Became head warden ('forst meister') in Brunnenthall-Steyerling, the property of Prince Adolph van Schaumburg-Lippe

1922
Radical designs of new log flume at Steyerling, which greatly reduced cost of bringing trees out of inaccessible mountains, with no damage to the timber

1924-1928
National consultant for timber flotation building successful flumes in Austria, Bavaria and Yugoslavia

1929
First patent applications for water engineering and turbines. This was a very creative time, and for the next few years he wrote a lot

1930-1932
Experiments with producing electrical energy directly from water, converting degraded into pure water and the prototype of the 'trout turbine' based on his observations of a trout's behaviour in a fast flowing stream. Study of comparative agricultural methods in Bulgaria, sanctioned by King Boris

1933
Publication of his only book, Unsere Sinnlose Arbeit "Our Senseless Toil – The Cause of the World Crisis"; subtitled 'Growth Transformation, not Destruction, of the Atom'. Meeting with Hitler to discuss Viktor's ideas about power generation and agricultural methods

1936-7
Arnold Hohl made detailed records of his visits to Viktor Schauberger, with contemporary writing , letters , notes and comments which were published in 1993 in a spescial edition of mensch und Technik-naturmass(humanity & Technology in according with nature

1938
Constructs with his son Walter a replica of Lord Kelvin's Falling Water Experiment of capillary research, generating a voltage of 20,000 volts

1940
The first Repulsine (flying saucer) built first in Berlin and then in Vienna, where the prototype broke from its mooring and smashed through the factory's ceiling. Heinkel steals Viktor's copyright and builds his Schriever 'Flying Top' in the Rostock factory

1943
Himmler gives the SS the task of producing secret weapons. Viktor gets sucked into the Nazi machine against his will

1944
Schauberger drafted into the SS and ordered (on pain of death) to develop an improved Repulsine and a submarine engine for Germany's war effort, at the Mathausen concentration camp. All prototypes and working models of the Repulsine subsequently ordered by Field Marshall Keitel to be destroyed on the collapse of the German armies

1945
Invading Russian intelligence team removes Viktor's research papers and his models from his Vienna flat. Held for a month in 'protective custody' by American forces in Austria who decided he was not to be deported to the USA, as were countless other German atomic scientists, engineers and physicists. Viktor starts work on his Klimator, for domestic air conditioning

1945-1950
Focuses on research to increase soil fertility and agricultural production

1958
Karl Gerchsheimer and Robert Dodd persuaded Viktor and Walter to go to Texas to discuss a project in which Viktor's research would obtain funding in America to develop energy-saving projects 'which could transform human living standards'. Within a few weeks, disillusioned with the whole project, Victor refused to cooperate. Desperate to get back to Austria, he unwittingly signed a contract which gave away everything for which he had striven, really destroying his life He arrived back in Austria on September 20th and within five days he died, a broken man

4.1 WHO WAS VIKTOR SCHAUBERGER

Viktor Schauberger was born on 30th June 1885 in the parish of Ulrichsberg in Upper Austria[113]. He was a true 'son of the forest', both from his heritage and his environment; There wasn't any doubt that he would follow his father's footsteps. He wrote once, *"From my earliest childhood it was my greatest ambition to become a forest warden like my father, grandfather, great-grandfather and his father before him"*.

Early he showed great interest in everything to do with Nature. He could walk around the whole day alone in virgin forest (compared to today) around Lake Plockenstein, studying animal and plant life, or following the wild mountain streams. He soon learned that not to be found in books about the life of the forest and about water from his father and elder relations. He says about them: *"They relied upon what they saw with their own eyes and what they felt intuitively. Above all, they recognized the inner healing power of water, and understood that water, directed through irrigation canals at night can yield a significantly greater harvest than that of the neighboring meadows and fields. Their chief interest, however, lay in the care of the forest and the wild regions."*

As Viktor reached the age to attend university, his father wanted Viktor, just like his brothers, to attend university in Vienna to train as an arboriculturist. Viktor saw things differently; he didn't believe in the education of the classroom but rather wanted to learn from nature itself. Famously, he believed the forest itself to be the best teacher – leading him to an unbiased and unfiltered vision of nature. Therefore, he broke the mold and attended the secondary school of forestry, where he was able to attain state certification as a forest warden, further gaining apprenticeship under an older warden[114].

After his studies, he pursued innovation and engineering. In 1922 came his first success – The wooden slide. This occurred when he managed to very efficiently drive the logs from higher altitudes to the valley on innovative water slides. This was such a success that he even received a promised award for this achievement. This did not go unnoticed by traditionally educated engineers, seeing as in their eyes, an uneducated individual innovated.

Though this invention got him success, he was unsatisfied and disappointed finding out that his own invention had led to the clear-cutting and the near-complete degradation of the natural environment. This deep sorrow of his first success led to him striving towards bettering the environment – hence the intense studies of understanding the living water from 1928 to 1935.

Therefore, one of Schaubergers aims was to investigate and artificially copy of the movement that he could see that the nature was using in order to gather energy for different uses. Fundamentally this movement could be described as an internal moving and twisting vortex. The vortex looks wide. A spiral galaxy is one example for a disc-shape vortex whose opponent could be a DNA molecule, which describes a nearly unlimited long thread-shaped vortex. The grade of complexity becomes obvious if you realize that large vortices are composed of smaller vortices and so on.

113 http://schauberger.co.uk/

114 Olof Alexandersson, Kit Zweigbergk, Charles Zweigbergk, Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.18-19

Schauberger meant that when these vortex systems are coordinated and phase together, huge forces are released. These forces are able of building or condensing biological systems and also rays of something that he named dia-magnetism. This dia-magnetism is is the opposite of gravitation and explains how it is possible for life-forms on the earth to grow up in the air.

Schauberger everywhere in the nature could see shapes that support this, as he named it, multiple centripetal movement. The beds of streams and rivers, the gills and fins on fishes, the wings of the birds, blood vessels and similar things, all these gives an impulse to this type of movement.

He tried to artificially generate the centripetal movement in various types of machines. Among other devices, he designed several prototypes that so called home power plants. These devices were conical shape, twisted tubes that were wrapped around a conical shaped body as a main component. Another design, an implosion machine that sucked in air that was twisted so efficiently that the dia-magnetic field was able to lift the device with a great force. However, the information on the function and efficiency of these devices is uncertain.

Viktor Schauberger died 1958, betrayed, side-stepped, and misunderstood 73 years old in Linz, Austria[115].

4.1.1 VIKTOR SCHAUBERGER AND WATER

"Water takes a central place in Schauberger's view of the world. It is the container of life and full of mystery."[116]

Water was his absorbing interest. He tried to discover laws and characteristics of water and the connection between its temperature and its motion. He observed the water that running from a mountain spring was at its greatest density, the so-called 'anomaly point' of +4°C, and at its highest quality Because of its molecules in 3-D structures and the electrical polarity, it can dissolve the substances. By freezing its volume increases by 9%, but it is lighter than in the liquid state. Salmon and trout drive themselves towards these sources, during their spawning, and in these spots there are the richest and most beautiful vegetation. During this early period as a forest warden, his experiences affected his understanding of water for the rest of his life[117] [118].

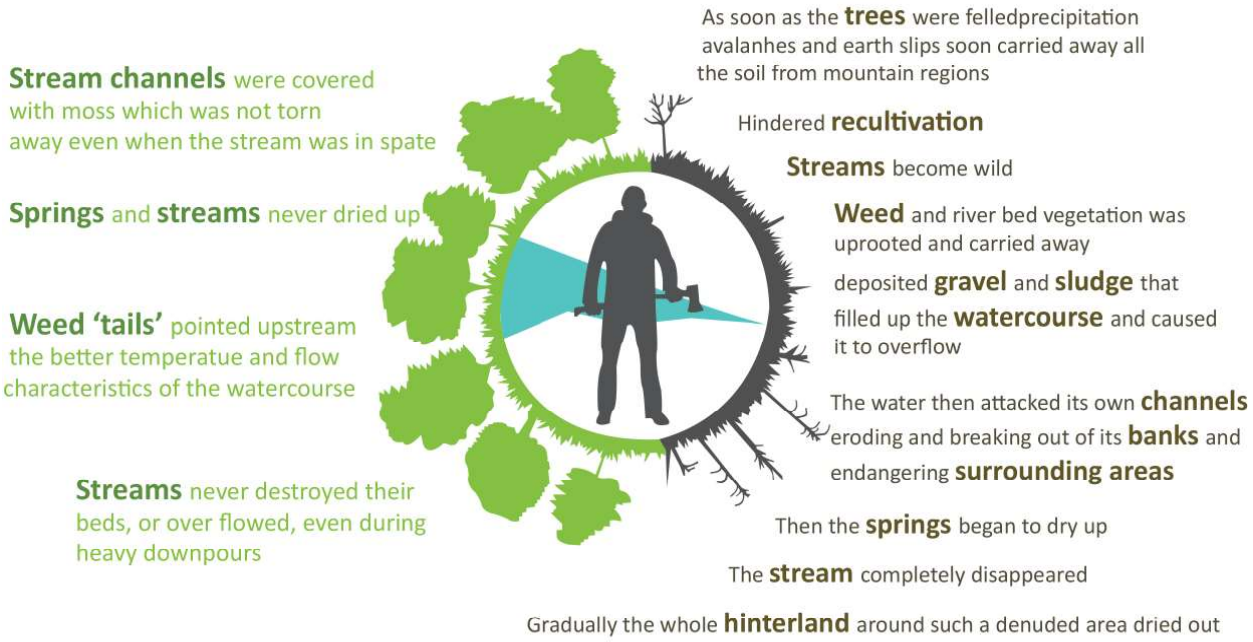
He realized water as 'the earth's blood', *"Were water actually what hydrologists deem it to be – a chemically inert substance – then a long time ago there would already have been no water and no life on this Earth. I regard water as the blood of the Earth. Its internal process, while not identical to that of our blood, is nonetheless very similar. It is this process that gives water its movement."* [119] and guessed that it must be allowed to flow along natural courses, if it was not to be spoiled. The water wants to flow in untouched water course (is shaped by winding curves and shaded banks covered with trees and bushes) and builds up shaded

115 http://www.newphysics.se
116 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.50
117 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.19-20
118 Adelia Bretetto, Homage to Viktor Schauberger, Viktor Schauberger a great precursor with a deep passion: water, Brussels, 5th April 2000
119 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.110

banks to protect itself from direct sunlight. He expressed that low temperature and natural flow was the necessary condition for water that can be supportive and carrying strength. He had seen how water could carry the greatest load on cold, in the clear nights, and he made early practical use of this observation[120].

4.1.2 SCHAUBERGER'S TECHNIQUES OF WATER MANAGEMENT

He was able to observe the dangerous changes that occur when man interrupts the natural harmony, it frightened him to see what happened to springs and water courses, to animal and plant life, when areas were deforested[121].



In his treatise in Die Wasserwirtschaft Schauberger describes the natural water regulation basis and shows how both the landscape and any adaptation of a watercourse affect the quality and health of the water. He showed how the surrounding temperature and other factors, changing the profile of flow in a watercourse and the different motions within the water, the rebel and laminar flow that have such an important effect on its 'metabolism'. He also showed in detail how with the construction of specific dams, the areas of land around the watercourses could be retrieved in a positive and natural way[122].

'Positive' and 'negative' temperature changes are an important factor within Schauberger's water theories. When the temperature range of water is approaching +4°C, the water's energy and its centripetal cycloid spiral motion is increased. The water becomes healthy, alive, and when the oxygen is bound by the hydrogen, the new water is built up through what he called 'emulsion'. Within 'negative' temperature range of water and warmed to over 4°C, is decreased energy and biological quality. The hydrogen is bound by the oxygen, then leads to the water's slow decline, its

120 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.19-20
121 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p. 34
122 Die Wasserwirtschaft, No. 24, 1930.

loss carrying power, the growth of pathogenic bacteria[123].

According to Schauberger's theories, water is a living substance which is born and develops, but with incorrect treatment, also die. Even a restricted volume of water can increase like an organism, not in the usual expansion through heat.

Water increases itself with naturally moving. Considerably quality of water and it matures improve. Its boiling and freezing points of water change, and in this case, water rise without using pumping equipment, to the highest mountain peaks, and appear as mountain springs. When in this context it is concerned with the natural process of diffusion and purification, this conception of raising water will be taken literally.

4.1.3 THE FULL AND HALF CYCLE

According to Schauberger, there are two kind of water cycle from the atmosphere to the earth and back, as a full cycle or half cycle[124].

The full cycle take place where there is the vegetation cover that in this way the rain can transpire deeply, it drains through the soil, sinking deeper and deeper through rapid cooling, until it achieves a level that the weight of the water mass above and the pressure of the deeply drained water are equal. Then, warmed by the earth's heat, and as its specific weight falls, wants to rise. In this way the water is able to attract and bind salts and metals. Actually, during heating, the water converted to steam, and comes into contact with carbon that exist under the earth, causing the reaction: C + H2O--> CO + H2; that means that the oxygen in the water separates from the hydrogen, and then the hydrogen gas wants to rise toward the earth's surface with an enormous pressure. Thus carbon dioxide is released from the deeper drainage basins. At the same time the gas dissolves and carried away surrounding salts to deposits them in layers near the surface, which is kept cool by the refrigeration effect of the vegetation. It will be an equable supply of feeding for vegetation, and is deposited at root level[125].

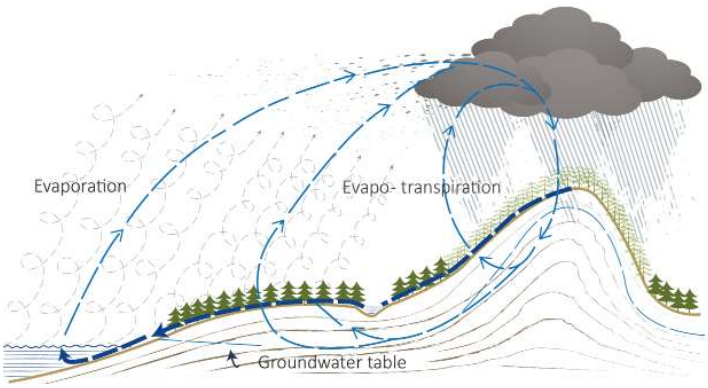


Figure 19: The full hydrological cycle
Alick Bartholomew, Hidden Nature, p.118

On the other hand, in half cycle, the surface area has little or no vegetation cover therefore the surface becomes warmed up by the sun. When the ground is warmer than the precipitation, the

123 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.49
124 Schauberger thoroughly investigates this in Hydrotechnology, No. 20, 1930
125 Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013, p.117-123

humidity is prevented from penetrating the soil. As the water go downs below the surface, it rapidly warms up and runs off, and it isn't able to bring up any of the nutritional salts. It also evaporates quickly.

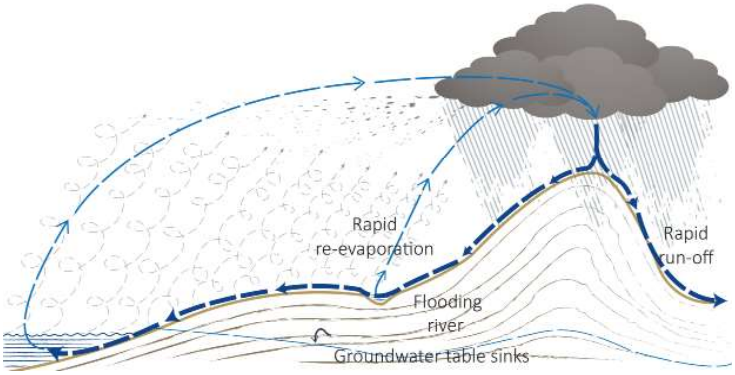


Figure 20: The half hydrological cycle
Alick Bartholomew, Hidden Nature, p.121

4.1.4 MANUFACTURED SPRING WATER

Viktor Schauberger had thought of producing drinking water with the best quality by using a machine that copied Nature's methods of making water. Because of environmental destruction, people couldn't obtain natural water, therefore this machine should be possible to create spring water.

As long as man hadn't disturbed the nature's balance and the earth was able to donate the water to prepare a healthy vegetation, there was no need for construct artificial canals. Today, however, the most of healthy springs are dried up or the water is diverted from its source and is flowed through badly constructed pipes, therefore, all of life is dependent on unhealthy water. Water supplied to houses through these kinds of systems is infected with chemicals. It is very important to rediscover Nature's ways for saving human, animals and the lands from decline[126].

4.1.5 THE TWO FORMS OF MOTION

Viktor Schauberger had perceived that exist two forms of motion within Nature of circulator's motion of water: one that breaks down, the other that built up and refines; both of them work in co-operation with another.

The form of movement which creates, develops, purifies and grows is the hyperbolic spiral which externally is centripetal and internally moves towards the center. We find it everywhere in Nature where growth or movement is taking place, in the spiraling of the nebulae in space, in the movement of our planetary system, in the natural flow of water, blood and sap. On the other hand, the destructive and dissolving form of movement is centrifugal in Nature it forces the moving medium from the center outwards towards the periphery in straight lines. The particles of the medium appear to be forced out from the center. The medium is first weakened, then it dissolves and breaks up. Nature uses this action to disintegrate complexes which have lost their vivacity or have died. From the broken- down fragments, new co-ordinated forms, new identities can be created

126 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.58

as a result of this concentrating form of movement. The centripetal, hyperbolic spiral movement is symptomatic of falling temperature, contraction, concentration. The centrifugal movement, on the other hand, is synonymous with rising temperature, heat, extension, expansion, explosion. In Nature, there is a continuous switch from one movement to the other, but if development is to occur, then the movement of growth must be predominant[127].

The secret of life is Di polarity

Without opposite poses in nature there is no attraction and repulsion.

Without attraction and repulsion there is no movement, without movement there is no life.

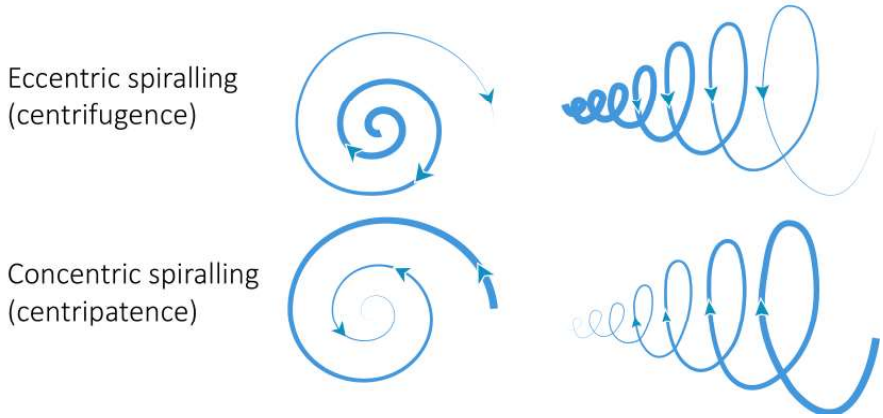
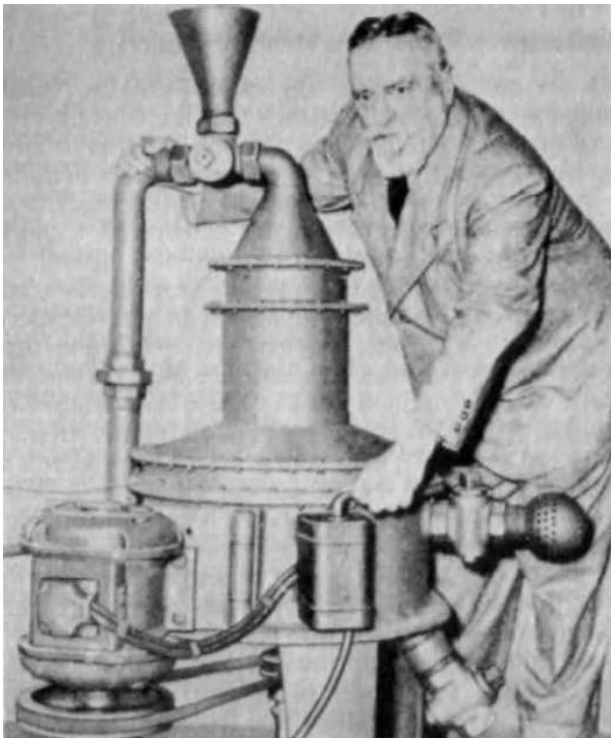


Figure 21: Eccentric & Concentric spiraling Frokjaer-jensen, Borge, Advances with Viktor Schauberger's implosion system , Ottawa, 1988

When the motion spirals counter-clockwise, it has a structuring and formative influence on material flowing (fluid or gas) in the implosion spiral. If it turns the opposite way around, its function is decomposing and disintegrative. The greatest vitalization is obtained when both spirals move inside each other. Such resultant or double concentric spiral movement is called the implosion spiral and constitutes the essence of Schauberger's implosion theory[128].

127 https://www.alivewater.com/viktor-schauberger
128 Frokjaer-jensen, Borge, Advances with Viktor Schauberger's implosion system , Ottawa, 1988

4.1.6 SCHAUBERGER PATENT



The following are the main patents of Schauberger machines considered most interesting for the purposes of this research project.

- **11 34 87 - Construction for Creating Wild Brooks & Flow Regulation":**

The construction for the creation of natural streams and for the modulation of the flow through the speed of water without any destruction of the watercourse due to barriers: the center of the flow is directed to the center of the stream.

- **13 45 43 - Lowering Water Level of The Rhine**

Concentration of the water flow inside ducts, channels and pipes with the aim of increasing the flow rate.

- **11 77 49 - Jet Turbine**

This construction uses a ribbed funnel to induce a swirling motion in the water; once the water reaches the bottom of the funnel it is sprayed onto a copper spiral turbine connected to an electricity generator in order to generate electricity.

- **14 20 32 - Water Refining Apparatus**

Schauberger built the first so-called water refining apparatus, and finally developed a model for which he sought a patent.

He sterilized water from the Danube with added small measures of certain metals, minerals and carbon dioxide, and in darkness let the mixture cycloid spiral motion, while allowing its temperature to fall towards water's 'biological zero' (+4°C). The whole process was a copy water's 'full cycle'. After a short storage period the water was allowed slowly to increase in temperature to +8°C, and was then ready to drink[129].

Anyway, outgoing water needs for every 10 liters output 1 liter of diluted salts in the following constituency and proportions:

Sodium Chloride (NaCl), 0.02 gr

129 Callum Coats, Living Energies, Viktor Schauberger 's Brilliant work with Natural Energy Explained, (July 5th 2001 by Gill &Mac Millan), p.197

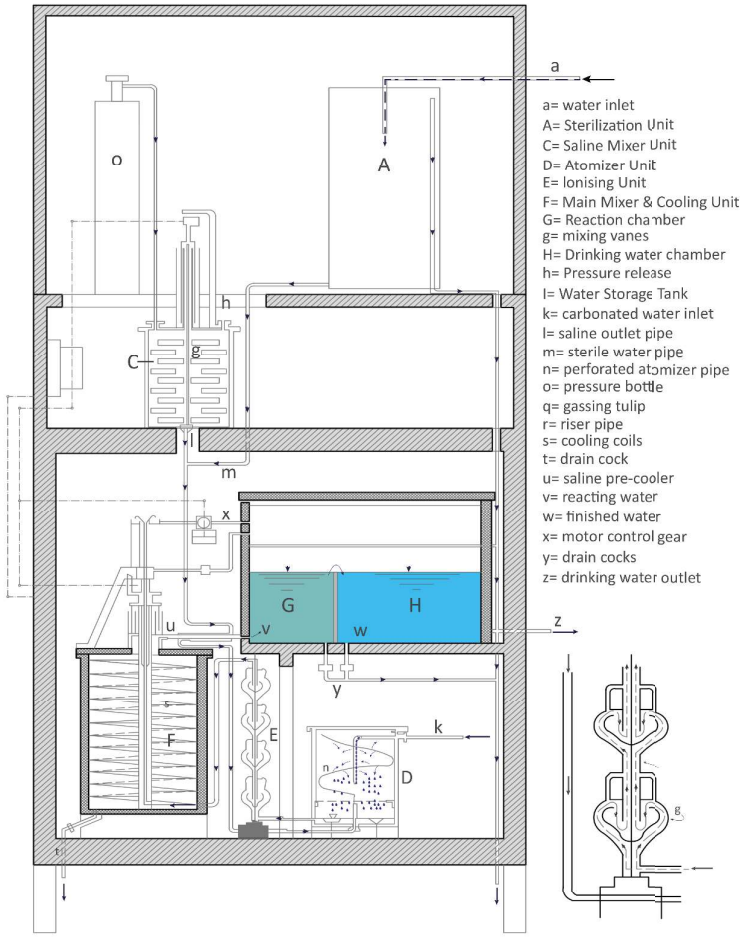
Magnesium Sulphate (MgSO4), 0.02 gr

Sodium Biphosphate (NaPh2), 0.02 gr

Potassium Nitrate (KNO3), 0.008 gr

Calcium Oxide (CaO), 0.2 gr

An earlier type of apparatus for the production of 'living water' Sterilized water from container (A) is mixed drop by drop with the salt solution from (C). The mixture then passes to (D) where it sprays out from the perforated pipe 'n', while carbon dioxide is being introduced via pipe 'k'. Water falls in droplets to the bottom of (D) while absorbing carbon dioxide, and is led to (E) where it is forced into a meandering motion into (F) where it passes over gold and silver filaments, to finally gather and cool in the silver lined container (H), until it slowly reaches +4°C.[130]



Rumor soon spread that Viktor Schauberger could make 'living water' and people streamed to his home to try it. They opinion was that the water was very refreshing; the sick felt better, fevers abated and recovery quickened. Schauberger had already been nicknamed 'water magician'. Specimens sent to laboratories for analysis showed that Schauberger's water could not be differentiated from spa water.[131]

130 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.60
131 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.61

- **13 82 96- A New Type of Pipe for Drinking water**

Improvement of the pipes and channels proposed in patent 134543, so that the water is led to the center of the pipe to force it to make a circular movement.

The Austrian Patent # 28099 refers to a tube capable of preventing the formation of encrustations and hindering the loss of flow velocity, whose section is given by several circular arcs, having the tube helical and starting from a cross section ovoid.

He was most critical of iron or concrete pipes, which he thought especially ruinous to water and a cause of cancer. He believed that the walls of our drinking water pipes must be made to encourage water to flow as it does in Nature. The material used for the main supply must be so chosen that it is organically compatible and above all a poor conductor of heat, like sound healthy wood. To discourage corrosion or rotting, pipes laid in the earth should be surrounded by sandy and not humus soil. The insulating quality of wooden pipes will reduce the deterioration that comes with temperature change in the water.[132]

The simple emplacement in the outer zone of the device will create turbulence between the center and the perimeter, so as to generate a well-defined flow zone in the center and layers of well-established stability from the perimeter inwards.

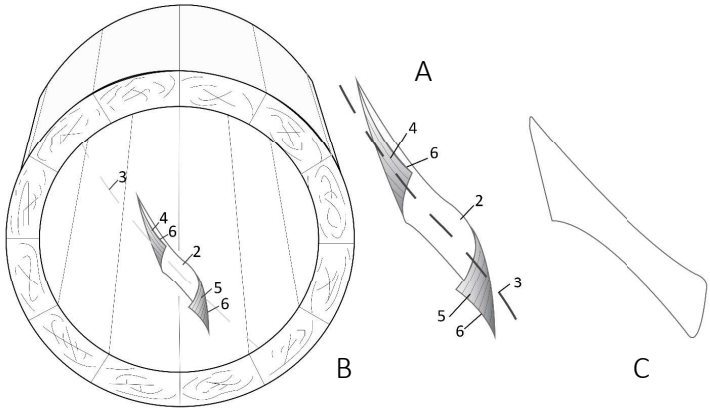
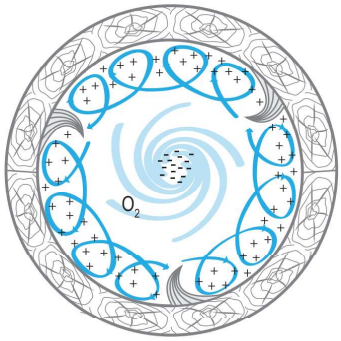
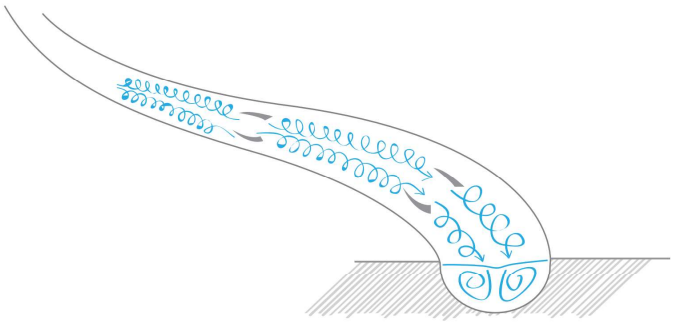


Figure 22: A double spiral pipe. The pipe, preferably made of wood, has guiding edges of pure metal (e.g. copper or silver) attached to the inside. These force the water into a spiral motion, which should increase its quality, while at the same time considerably reducing the resistance in the pipe.
Austrian patent13 82 96

The emplaced devices are of the kind illustrated in Figure A, where we have an element (2) with its two ends bent (4)-(5) and striations dug out at the back (6); this device, when inside the tube (1) as seen in Figure B, will meet the incoming flow and twist it along the new path (3), so as to create circular motion in the liquid. Figure C shows the device of Figure A straightened out so as to show its true shape.





132 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.64-65

- **Egg Shaped Apparatus for Biosynthesis**

Schauberger tried to construct a more 'natural' model for refining the water and after a while he developed that apparatus. Schauberger choose the shape of an egg, which he considered Nature's most ideal form.

The vessel had a vacuum-tight lid which allowed filling and draining with an inlet for carbon dioxide. There was a meter for measuring the 'biological vacuum' that should build up within the container, if the process was to function correctly.[133]

An egg should be filled to the brim with spring water (under no circumstances should it contain any chlorine) or aqua distillate or carbonated water (soda siphon water). Starting temperature should not exceed +27°C (+80.6°F). First attempts should be made using well-boiled well-water, which should be allowed to cool to +17°C (+62.6°F) before being poured into the egg. In this regard the water must be poured in very carefully to avoid entry of any sediment. All foam and surface scum to be skimmed off.

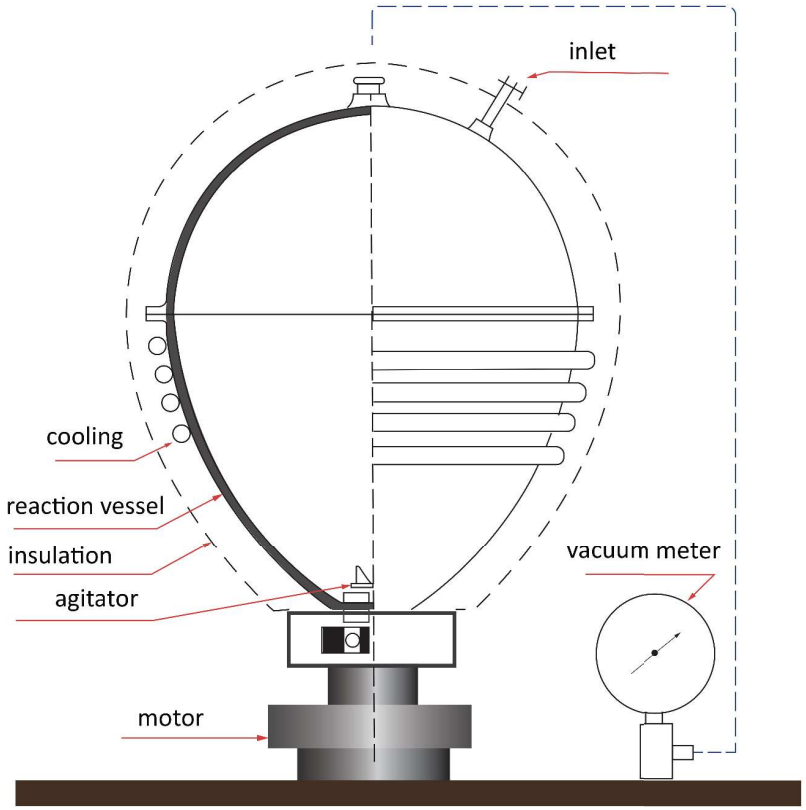


Figure 23: Repulsator design from the Swedish Biotechnical Research Institute, Instructions from data provided by Viktor Schauberger
Viktor Schauberger, Callum Coats,The Energy Evolution,p.161

133 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p.61

Two opaque, dark bottles (beer bottles, for example) should be half-filled with the above water, one of which should receive the prescribed quantity of calcium and the other, the three other ingredients or sediments. It is very important that one bottle should be filled with calcium only. The two bottles are then shaken thoroughly for a few minutes until the water in both has become milky. The bottle containing the three sediments should be poured into the egg first, followed by the bottle containing calcium. The latter should be handled with care and should be stored in the dark. At first the water appears milky, but clears itself during the in winding process[134].

Sufficient carbon-dioxide should then be introduced in order to expel the last traces of air. This is best done with a vacuum pump, whereby any desired quantity of carbon-dioxide can be admixed, or whose addition can thereby be regulated. Regulation is also possible with the reduction valve. The right quantity of carbon-dioxide can only be determined by experiment, which is possible by tasting the finished water. If the carbondioxide is noticeable, then too much has been added. If the water is too hard, then the amount of calcium is excessive. Whatever ingredient or sediment comes to the fore must be reduced in quantity. If the water is insufficiently refreshing, then the magnesium should be increased. The mixture is correct if no sediment or carbon-dioxide is particularly noticeable in the water. If the water is insufficiently invigorating, then there is not enough carbon-dioxide.

The agitator stirred the water in a cycloid spiral motion. The critical factors of this apparatus were: agitator's shape, the number and direction of revolutions and certain rhythm in 3/4 time.

The materials used in his 'egg' were very important; he experimented with different alloys of 'pure metals', finally he found one he considered suitable. The vessel for preventing the energy created from radiating outwards also had to be well insulated with a suitable material. This energy should instead be returned in the water to give it its high quality.

The external temperature during the regenerative process should be at least +3°C (+37.4°F), since it effects the internal temperature. After completion of the fermentation, then the external temperature should be maintained at +4°C (39.2°F). Maturation takes about 24 hours and should take place in the egg itself or in clean glass vessels stored away from all light and heat.

When analysed, the finished water should be deficient in oxygen. The water actually still contains oxygen, although it is bound by the carbondioxide. The water's potency is increased in this way, which is not the case in soda siphons.

The water should only be drunk in small quantities at temperatures not exceeding +7°C (+44.6°F), for the water already begins to deteriorate at +9°C (+48.2°F) and therefore it should always be transported in thermos flasks to prevent the temperature rising above +7°C (+44.6°F). Drinking this water provokes strong elimination or excretion, because all waste matter is expelled from the body. The appetite is strongly stimulated. Diamagnetism disappears after 24 hours, which impairs

134 Viktor Schauberger, Implosion Magazine, No. 36, pp 30-32

the healing effects[135].

Ingredients required for about 10 litres of Water[136].

Potassium (K) = 0.0034 mg/kg	Chlorine (Cl) = 0.0257 mg/kg
Sodium (Na) = 0.0776 mg/kg	Sulphate = 0.1301 mg/kg
Calcium (Ca) = 0.0215 mg/kg	Bicarbonate = 0.0638 mg/kg
Magnesium (Mg) = 0.00039 mg/kg	Nitrite = 0.0001 mg/kg
Iron (Fe) = 0.00042 mg/kg	Fluorine (F) = 0.0028 mg/kg
Manganese (Mn) = 0.0001 mg/kg	Thiosulphate =0.00055 mg/kg
Lithium (Li) = 0.00022 mg/kg	Malic acid = 0.0754 mg/kg
Strontium (Sr) = 0.00047 mg/kg	Metaboric acid =0.00497 mg/kg
Aluminium (Al) = 0.0002 mg/kg	Free CO2 = 0.0054 mg/kg

- **Trout Turbine- New Motor Fuel Through Biosynthesis**

The trout through its mouth, and expels it through its gills can takes in water. through the microscopic edges of the gills, like the hyperbolic centripetal spiral movement, the water is given a strong movement. Water achieves new physical characteristics through the simultaneous influence of certain effects of elements found within the gills, that Schauberger termed these changes to 'juvenile' water. The water that flows from the gills along the body of the fish reacts forcefully with the surrounding water because of its different make-up. This result in a secondary system of water circulation being formed which resists the water's natural flow in the stream. By regulating this pressure with the gills, the trout can either stand stock still or move lightning fast against the stream[137].

Viktor Schauberger explained that the pressure of the vortices pushes the trout upstream, much like squeezing a wet bar of soap. By opening its gills the trout can increase the intensity of the vortices it generates, and hence how much energy it can extract. In essence the trout can remain almost stationary in the flowing water with just a gentle sway to keep itself aligned with the flow.

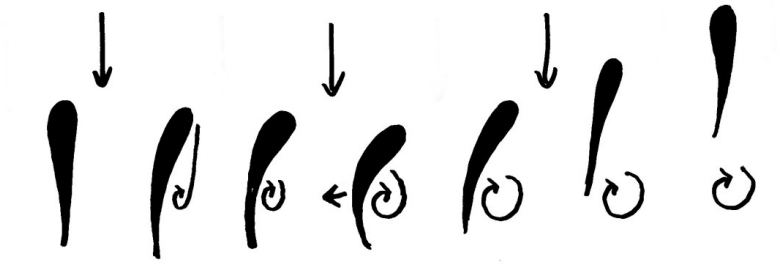


Figure 24: the motion of the trouts body; increasing the intensity of the vortex
http://theartofnature.org/id20.html

135 Viktor Schauberger, Implosion Magazine, No. 36, pp 30-32
136 Viktor Schauberger, Callum Coats, The Energy Evolution, harnessing free energy from nature, (5th October 2000), p.163
137 http://theartofnature.org/id20.html

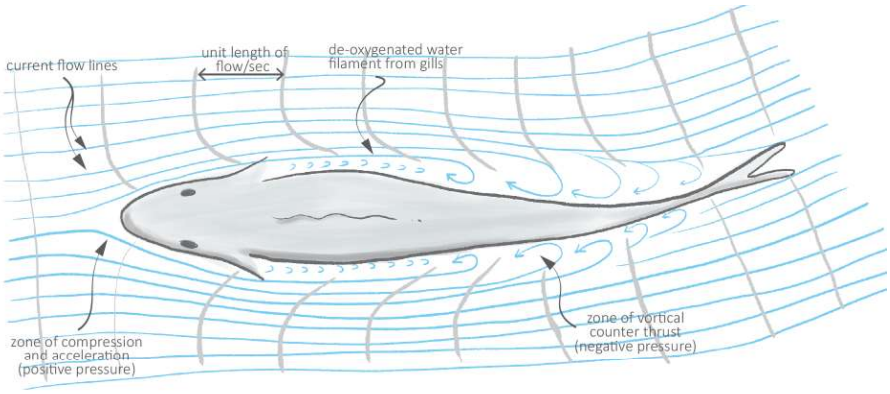


Figure 25: The stationary trout. The trout normally swims in the middle of the central current, where the water is densest and coldest. Its body displaces and compresses the individual water filaments causing them to accelerate. As their critical velocities are exceeded, vortices or countercurrents are formed along the rear part of the trout's body, providing a counterthmst to the current, allowing the trout to remain stationary in the fast flowing water. If it needs to accelerate, it flaps its gills, creating a further vortex train along its flanks, increasing the counterthmst upstream.
Alick Bartholomew, Hidden Nature, p.27

The principle of this machine was that elements such as air and water should be directed through the spiral shaped pipes of a particular material, and with specially shaped cross section. The introduced element should then, at a certain count of revolutions, be directed into a corkscrew motion, at which point the energy should be released. Schauberger presumably counted on a certain reaction at an atomic level, something akin to hydro-fusion experiments all over the world. However, instead of violently compressing atoms in hydrogen gas to create helium and a release of energy, Schauberger wanted to 'screw' together his elements without resistance, in the same way as he perceived it to happen in Nature[138].

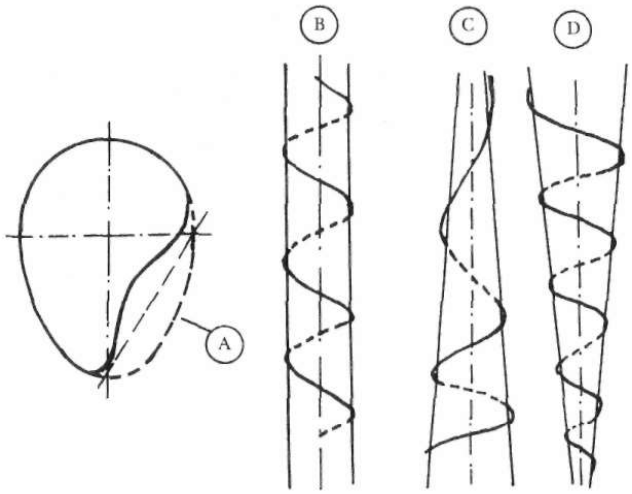


Figure 26: Pipes for liquids and gas. This pipe was also to be used in the 'Trout turbine'.Its cross section is shown in (A). (B), (C) and (D) are different designs of spiral.pipe systems, showing the pipe to be wound around cylindrical and conical objects.
From Austrian patent no. 19 66 80

138 Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan), p. 85

After that Viktor Schauberger made the biological submarine look as though it were not very useful, as in his opinion, biotechnology is for supporting progress and not for destruction. This submarine idea was taken from the observation of fish, especially of trout, which can stand motionless in a flowing stream, just by taking water in and out. This process has two functions, first it creates a vacuum in front of the mouth into which the fish gets sucked, and at the same time provides food, as the water contains all that the fish needs. While the food goes into the digestive system, the water is forced through the fan-like structure of the gills, which not only absorb the oxygen needed, but also push the water backwards. This specially compressed water does not mingle right away with the rest, it glides along the conical body like a wedge and shoves it forward. In addition, on the scales it forms little whirls which enhance the push further[139].

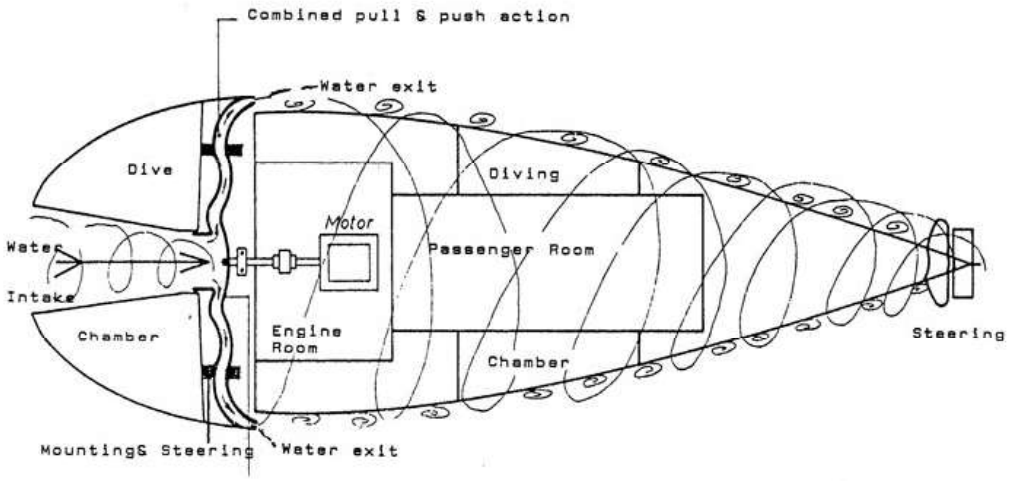


Figure 27: The biological submarine
http://www.disclose.tv

139 http://www.disclose.tv/forum/the-third-reich-the-vril-gizeh-intelligence-t61692-10.html

4.2 OXYGENATION

The vortex investigated by Schauberger has found practical applications in oxygenation and in the treatment of separation of contaminated water.

Inside the vortex, a low pressure area is created in which the rotational speed increases and within which the hydrophobic substances converge which can then be separated. In the vortex, the system enters a state of dynamic equilibrium, in constant change while keeping the structure stable.

Experiments on oxygenation systems conducted by different research centers (Kullberg, 1982) have shown that the technology can be used for the oxygenation of fresh water and consequently for the elimination of bad odors, for example from hydrogen sulphide. It has also been shown that iron and manganese ions can precipitate more easily through the vortex. This means that the technology has potential applications to the treatment of drinking water, and implies the possibility of reducing the dependence on chemicals for the separation of metal ions.

In fact, thanks to the action of the vortex, micro bubbles of oxygen are created which facilitate diffusion into the surrounding fluid mass. This system could therefore complement existing flotation systems and on a larger scale could be used to regenerate lakes and river.

4.2.1 THE PLANE PUMP

Schauberger developed an arrangement for pulling down oxygen to the bottom of lakes, and then it was patented in 1968 by his son Walter. The disadvantage of direct stirring is the difficulty to sustain a vortex when the system is scaled up.

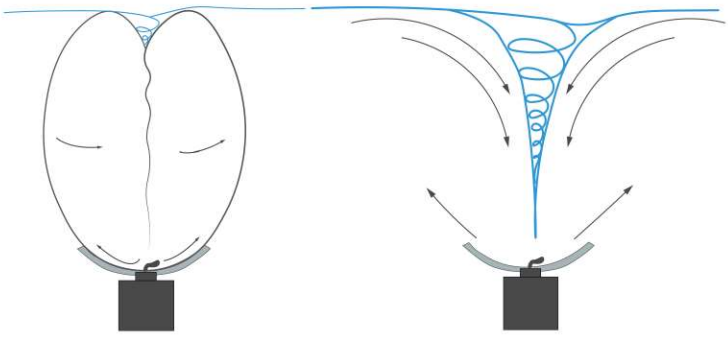


Figure 28: [A] Schauberger's oxygenator [B] Since the induced motion mainly is a rotating one, a water body is created, with little contact with the surrounding water.
Austrian Patent No. 265991, 1968

The Plane Pump is a device designed by Schauberger that allows the water contained in a container (preferably with an oval section) to have a toroidal movement, creating a vortex in the center of the container itself. In the Plane pump two circular plates, joined by radial guiding rims, are brought to rotate. Through a pipe in the middle of the upper plate, water is being sucked in and is then ejected towards the periphery due to the centrifugal force. Since the pipe can be made narrow, a substantial sub pressure can be created. The swirling effect in the water is enhanced by the rotation of the plates. The surrounding medium quickly organizes itself to a toroidal vortex flow[140].

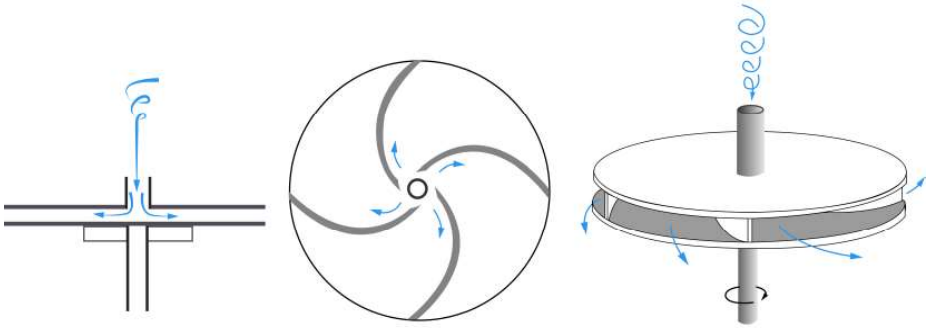


Figure 29: The principle of the plane pump. Water is sucked into the pipe in the middle and is thrown out radially towards the periphery.
IET, Self-organizing Flow Technology,P.26

A possible application is in induced gas flotation, water clarification treatment for the removal of suspended solids or hydrocarbon flotation, through an effective mixing of air bubbles in a fluid, which normally requires a certain amount of energy to dissolve air in pressure in the water. With the plane pump designed by Schauberger this problem is solved because the water follows a toroidal movement and the micro air bubbles follow a radial direction that allow them not to immediately go upwards having a more effective diffusion. Another interesting application is in waste water treatment.

In addition, some tests conducted using the Aquagyro device combined with sand filtration show how it is possible to observe a greater precipitation of manganese and iron ions compared to untreated water. Specifically, the experiments conducted in the Paltrask research center in 1990 show a reduction in the concentration of Manganese from 0.26 mg / l to <0.05 mg / l and of Iron from 0.23 mg / l to 0.21 mg / l[141].

During the same tests there was a sharp increase in oxygen concentration from 0.4 mg / l to 10.5 mg / l.

A subsequent test conducted at the Vistbacken research center shows a more marked reduction in the precipitation of iron ions using the Aquagyro system (Johansson, 2002).

140 Lars Johansson, Morten Ovesen, Curt Hallberg, Self-organizing Flow Technology- in Viktor Schauberger's Footsteps, Institute of Ecological Technology Scientific and Technical Reports – 1, Malmo – Sweden – 2002, p.26
141 Aquagyro AB, Pilotanlaggning i Alvsbyn Information brochure from Aquagyro AB, Umea 1991

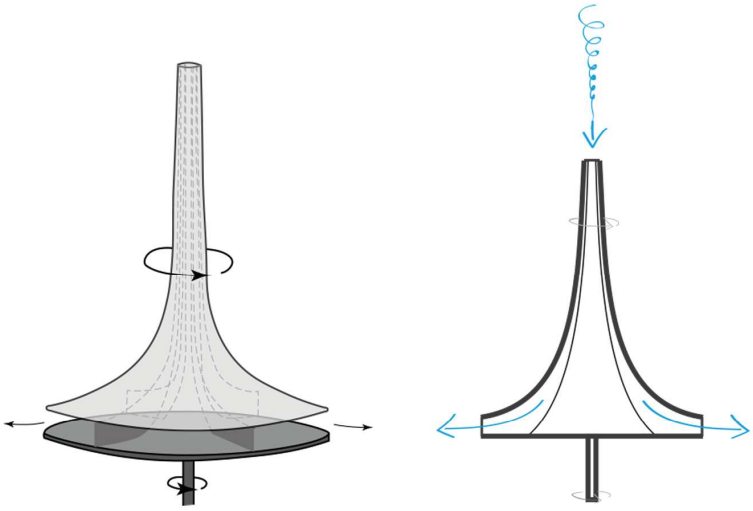


Figure 30: The Aquagyro
Swedish Patent No. C2 500 416, (8903548-9)

Oxygenation at a small scale was investigated in 1988 by Nordell and Nordmark. A small Aquagyro stirring device was placed in an egg-shaped vessel and after one hour the water had reached a good level of oxygen saturation.

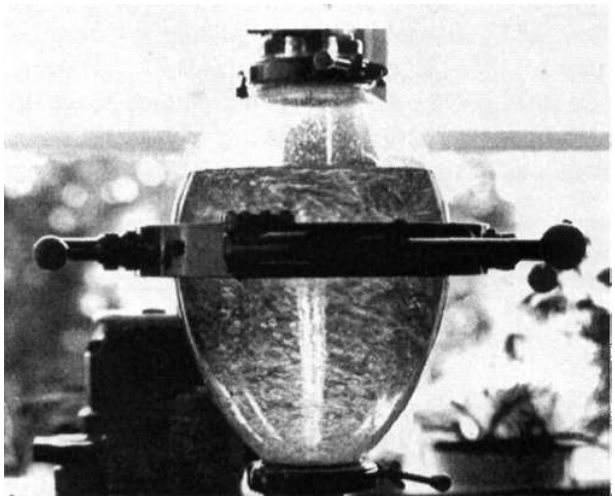


Figure 31: The Repulsator
IET, Self-organizing Flow Technology,P.29

4.3 APPLICATION OF SCHAUBERGER THEORIES

Over the years, Schauberger's machines and patents have aroused the interest of many research groups and stimulated the development of various devices to enhance the quality of water based on alternative treatment methods.

By alternative methods we mean here those systems that use the properties of water to respond, for example, to electromagnetic stimuli or to simple movement to change its characteristics without having to resort, for example, to the use of chemicals.

The systems taken into consideration during this analysis phase are systems that use vortex technology (Martin Wasserwirbler, Plus & minus, Aqualife), magnetic devices, devices that use electromagnetic treatments (TFF, Rai & Singh, Violette water), etc.

Some studies have determined an increase in the performance of water subjected to alternative treatments compared to normal bulk water both in industrial processes in a microbiological environment (for example on contact lenses and water treated with (PlocherTM-System), and on the increase in performance , of the growth rate and vitality of plants (Voithofer 2004, Hacheney 1992) Some applications on lakes affected by strong eutrophication have shown significant benefits following treatments using vortex technology (Holst, 2004).

On the other hand, a large study conducted by the University of Vienna (Hammer 2004), would not have been able to produce significant results with respect to the variation of surface tension, the growth of bacteria and that of plants by comparing simple tap water and water. tap water treated with Grander technology.

The real effectiveness of these systems is therefore difficult to prove, especially since they are systems that affect the quality of the water that are difficult to measure with traditional techniques.

4.3.1 SPIRAL PIPE SYSTEM

According to Austrian Patent 196 680, Viktor Schauberger suggested a spiral pipe for the natural behavior of drinking water. A space-saving variation was introduced by the Implosion research group, Zell am Harmersbach, who, working together with Erich Neumann, developed a spiral pipe. They are intended for application in house water supply, in the garden and in agriculture.

The pipes are based on a 22 mm installation pipe (soft copper). Through successive dents, the pipe takes on an egg shape profile. These proceed in a spiral. It follows that the excellent properties of the pipe transfer to the water as well as its environment.

The tubes are delivered as bars with different lengths, no more than 1.5 m. They have a round end of approx. 3 cm in length on both sides, which makes inclusion in a conventional piping system easier. To this end, any standard fittings with a 22 mm welding connection can be used. Where

required, the tubes can be straightened with any lengths between 0.5 m and 1.7 m[142].

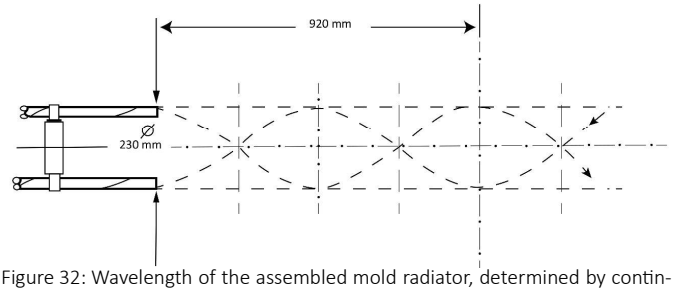


Figure 32: Wavelength of the assembled mold radiator, determined by continuing the spiral-shaped indentation on the cross-section of the radiation beam
Verein für Implosionsforschung e.V., Anwendungen des Spiralrohres, p.14

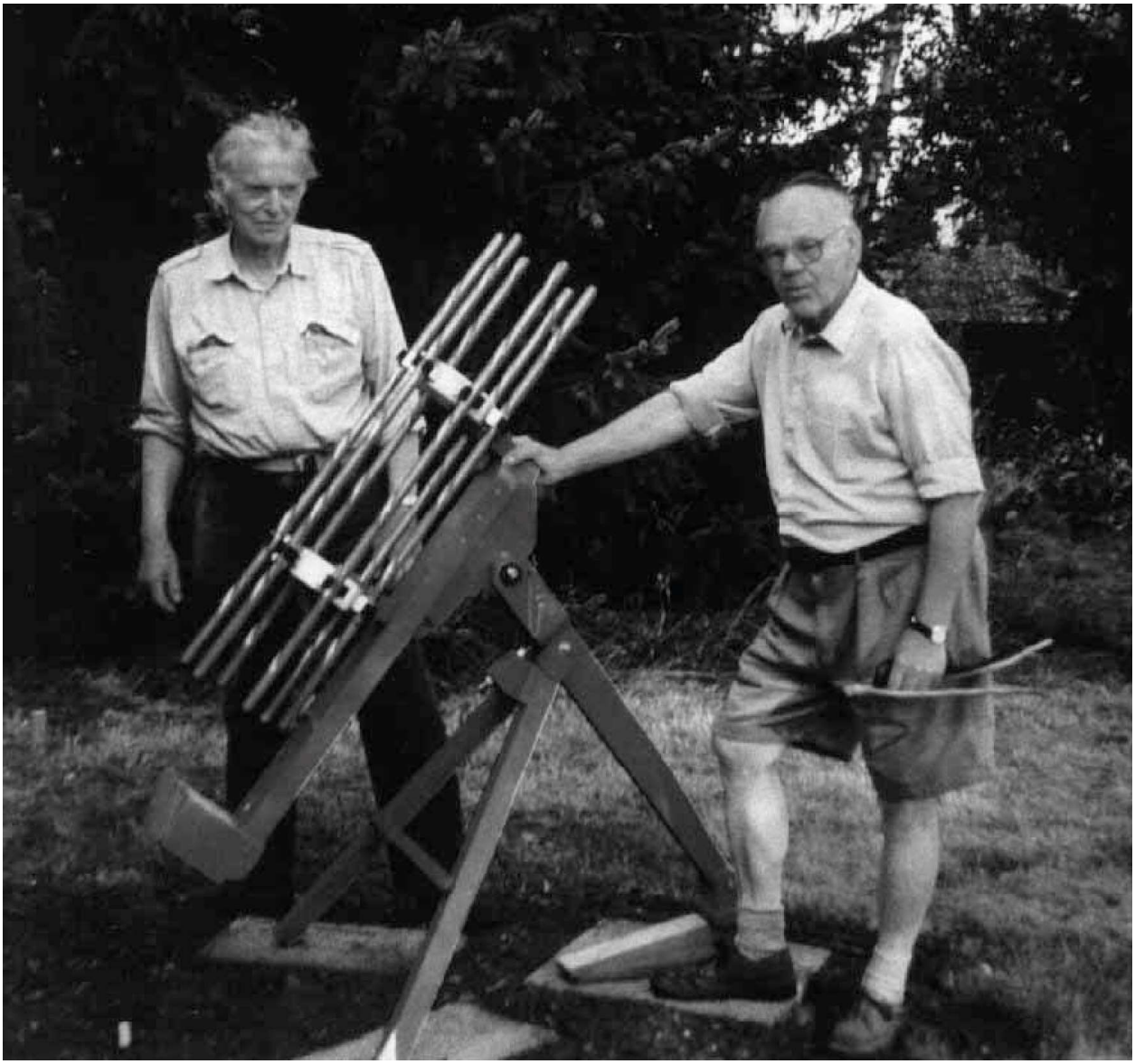


Figure 33: In the foreground of the great EM-form radiator inventor and author Erich Neumann during a test series in 1997. In addition, his friend and collaborator Ing. Klaus Deutenberg.
Verein für Implosionsforschung e.V., Anwendungen des Spiralrohres, p.3

142 http://www.implosion-ev.de/

4.3.2 HYPERBOLIC FUNNEL FOR WATER VITALIZATION IN BIOTOPES

Here the water will be tangentially guided in the funnel (modeled in accordance with Walter Schauberger hyperbolically formed sound law formula).

Rotating water curtain is formed on the bottom end a pear-shaped, thin. So, there is a larger water surface with considerable impact, as the distributor, Klaus Rauber from the Verein für Implosion Forschung (Society for Implosion Research), writes as follows:

"The natural swirling movement gives water back its constructive forces. Furthermore, it reduces harmful substances in water and incorporates additional oxygen und carbonic acid and does so with minimal expenditure of energy. Observations over many years show:

- *Green and Filamentous algae will be reduced in a natural way.*
- *Water turbidity disappears by means of brown algae.*
- *The oxygen supply for fish is improved.*
- *Plant irrigation requires approximately 30% less water."*[143]

Figure 34: . Copper funnel for use in Biotopes

4.3.3 FLOW FORM

The Flowform technology developed by John Wilkes essentially consists of three-valve flow forms, in which the flowing water describes a lemniscate.

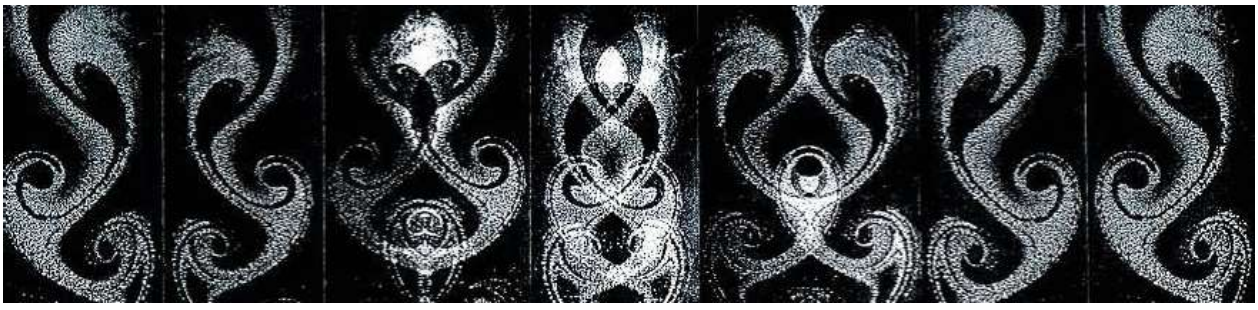
In its natural environment, water expresses of different rhythms, such as the falling and rising of the tides, and the rhythmic patterns of waves rolling to the seacoast. By its inner rhythmic nature, water also shapes and imprints patterns into its natural surroundings, with the meanders in a river or a river delta, or the rhythmic patterns in sand. Patterns similar to Flowform designs can be created through natural erosion processes, such as on Ayers Rock in Australia.

143 https://www.implosion-ev.de/

Figure 35: Waterfalls streamed down Uluru on March 22, 2021. PARKS AUSTRALIA
https://www.atlasobscura.com/articles/uluru-waterfalls

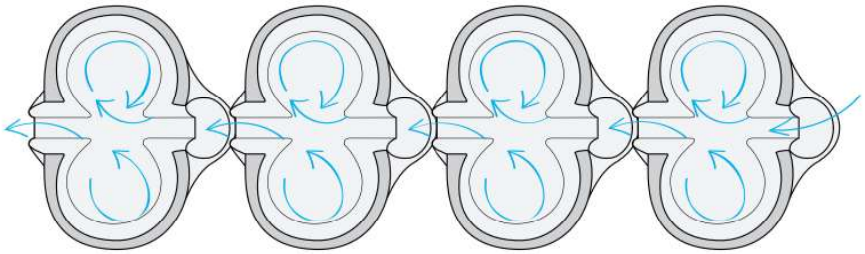
Wilkes thought that symmetry in life forms could be considered as a higher level of being and he propounded the question whether the use of symmetry in connection with streaming water could lead to a higher condition in the quality of the same water (Wilkes 2003). Wilkes made a symmetrical channel of varying proportions with a smooth slope and introduced flowing water through it. At a specific place an unexpected rhythmical oscillation occurred.

The Flowform vessels provide not only for demonstrating the phenomenon of rhythmically pulsing water artistically, they also enable a wide range of applications influencing biological and botanical processes through the rhythmical movement of water, remembering that all life processes are themselves always rhythmical. Thus artistic and technological applications can be combined in mutual harmony[144].



144 Dr Joachim Schwuchow PhD, John Wilkes ARCA, Prof. Costantino Giorgetti Eng, Iain Trousdell BA, Iain Trousdell BA, Alison Trousdell BA, FLOWFORM WATER RESEARCH, A Collation of Research and Related Ideas, Healing Water Institute, 1970-2007, P.6-7

Attraversando queste forme l'acqua è indotta a descrivere la forma dell'otto, un otto aperto però, che è anche il symbolo dell'infinito. To realize a vorticous and rhythmic motor, it is necessary to draw the appropriate geometry. In fluid dynamics, the Reynolds number indicates, for a specific situation, the transition from laminar to turbulent motion.



Some tests carried out on the Flowform show differences in water oxygenation, organic content and pH. A study conducted in "The Channon" in Australia shows that BOD decreased from an average of 424 mg / l to less than 20 mg / l after a period of 105 minutes. Over the same period, bacterial colonies of fecal coliforms decreased from an average of about 3100 cfu / 100 ml to a level of 500 cfu / 100 ml and the amount of dissolved oxygen increased from 0.1 to 3.9 ppm .

A comparative study between the Flowform system and a traditional air blowing system conducted in 2009 at the "Laverstoke Park Farm Laboratory in England, showed that the concentration of oxygen in the water treated with the Flow form lasts longer than the treated one. with the traditional method. This allows the Flowform system to more effectively support microbiological growth. (J. Williams, 2009). The influence of parameters such as density, temperature, viscosity and flow on the flow-form rhythm was investigated at the "University of Lulea" (Sweden) by Martin Strid.

4.4 STRUCTURED WATER

"Comprehend nature, then copy Nature."- Viktor Schauberger (1885-1958)

The qualities of vortexed water were best described by Viktor Schauberger. He established solid evidence of the huge difference between "dead water" and "living water." "Dead water" is still water such as bottled or distilled water. Living water, as he taught, is like the water found in springs and rivers that forms spirals and vortices as it flows causing higher zeta potentials (life force), higher ionization, oxygenation, kills parasites and bacteria, as well as raising the body's electron count.

The researchs by Dr. Mu Shik Jhon of Korea(1932-2004) showed that in a vortex the inner layers of water flow much faster than the outer layers, and that the velocity at the center of the vortex is infinite. The hydrogen bonds in the water molecules begin to stretch as these layers expand and contract. This opens the molecular structure of water for a constant interchange and exchange of electrons. As hexagonal structuring increases, the water's ability to carry vibrations and frequency information also increases. Dr. Jhon understood the importance of this vortex effect to restructure water.

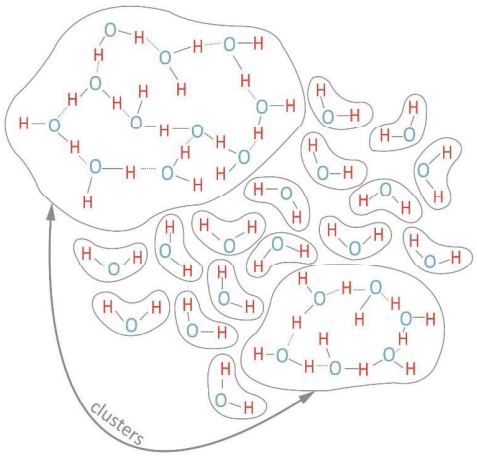


Figure 36: Structure of most water: Groupings of interconnected
http://www.chem1.com/acad/sci/wat-images/watclust.gif
Figure 37: water molecules in the liquid state

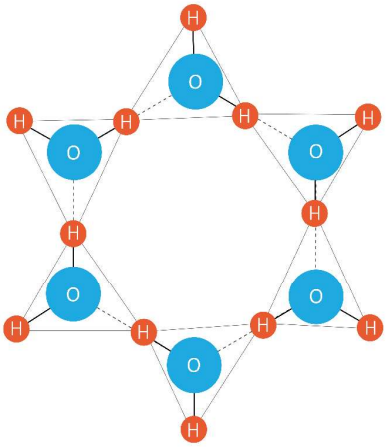


Figure 38: Hexagonal water ring
http://www.aquatechnology.net/hexagonalwater.html

All water is a network of hydrogen-bonded molecules. Water is mostly of a pentagonal structure that can form numerous structures, depending on how the individual molecules bond together. Fig. above shows how most water is randomly structured, with different sized clusters all held together with hydrogen bonds.

Hexagonal water, a where 6 H2O units consistently link to form a ring-like structure. Essentially, it is more organized than 'normal water', forming a crystalline lattice like that found in pure rain and fresh snow. The number of hexagonal units in the water determines its ability to enter the cells in the body. The hexagonal structure is easily destroyed by environmental contaminants and modern water treatment processes, which is the reason most water has few hexagonal units[145].

Hexagonal water molecules also have a unique bond angle which allows for straighter, stronger bonds. Regular tap water has a bond angle of 104.5 degrees between hydrogen and oxygen atoms. **Hexagonal water has a 109.5 degree angle - a wider angle which creates a 3-dimensional pattern. This is considered the "perfect" tetrahedral angle for water where each water molecule serves as the donor and the acceptor of 2 electrons.**

"...cells surrounded by less structured water are weaker and more prone to malfunction and genetic mutation."–Dr. Mu Shik Jhon

Hexagonally-structured water allows rapid penetration within the cells of the body. This allows for cellular communication, intracellular water movement, enzyme function, cleansing of the body's cells, efficient transport of nutrients into the cells, greater stabilization, superior hydration, electrical communication between cells, and many other metabolic processes.

145 http://www.aquatechnology.net

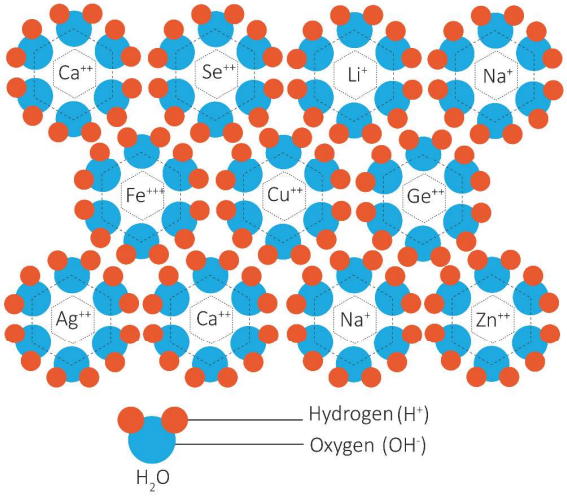


Figure 39: Hexagonally shaped water- Pollutants and toxins are unable to bond with water molecules – this prevents toxin accumulation and cellular problems.

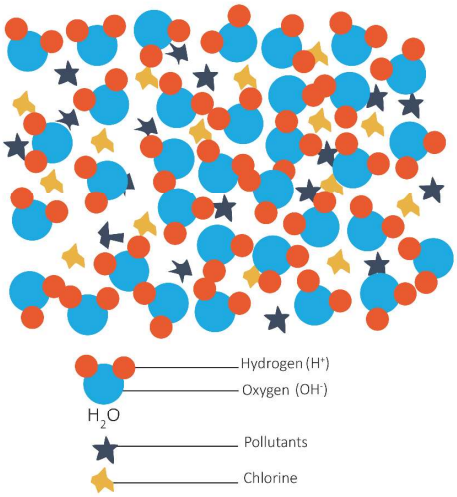


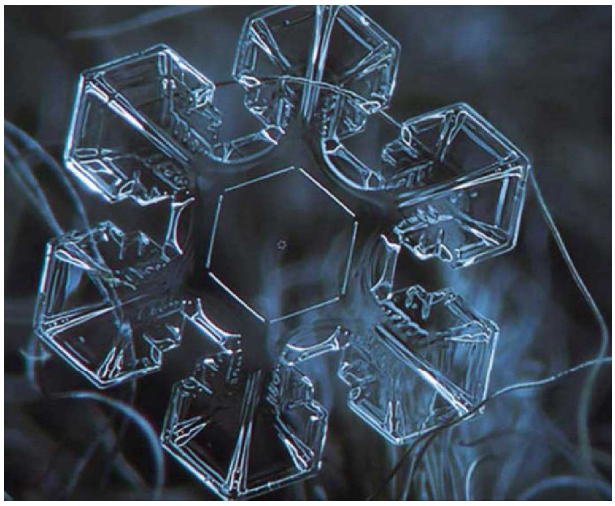
Figure 40: : Most tap water and bottled water- Pollutants and toxins can easily bond with water molecules. This creates toxic accumulation and cellular problems.

On the other hand, portrays that most tap water and bottled water is composed of large water conglomerates which are too large to move freely into the cells. This structure allows toxins to build-up in the body.

4.4.1 EFFECT OF STRUCTURED WATER ON HUMAN BODY

Water inside the body's cells is structured water. Structured water is found in the cytoplasm of healthy tissue. It has a high solubility for the body's minerals, so minerals and vitamins, which are formed with structured water, tend to go from the digestive tract and bloodstream into the tissues. The water preferred by human cells is structured into small clusters containing 5 to 20 molecules. As the human body grows older, it is subjected to stress, contamination, pollutants, free radicals, poor diet and other external factors. The body begins to dehydrate and the structured cell water present at birth begins to diminish, losing its effective shape. The result is that the ability to absorb water begins to decrease with aging. The key to hydration lies more in the structure of water than its pH. Only water that has been sufficiently structured can enter a cell and deliver the oxygen which ignites the hydrogen that the cell and the body run on.

Another attribute special waters have in their structure is called 'hungry water', the ability to attract and encapsulate within the water molecule elements bad for human life. When this water is consumed it attracts more of these elements as it passes through to the elimination system. Elements good for human life ride on the exterior of the water molecule and are released into the body's function.



Structured water is highly stable. It frees excess oxygen. It supports aerobic bacteria and kills anaerobic bacteria. Consuming structured water instantly hydrates the cells. In the QXCI machine, you would instantly see the results in twenty-two seconds, from the time you think you're going to pick up the glass and drink from it. What happens when we drink tap water, our body expends around one hundred KW of energy to be hydrated. With structured water, our hydration is instantaneous and our energy can do what it's meant to do, It resets DNA and RNA back to before circumstances and pollution.

The best thing to be understood about structured water is that by changing the molecular structure of the water (cluster sizes get measurably smaller, surface tension is reduced for greater ease of hydration), any materials in the water are also structured (neutralizing their ability to be assimilated in the body), and the information that the water had carried will have been erased. This creates life-giving rather than energy-taking water[146].

4.4.2 HOW DOES VORTEXING CREATE STRUCTURED WATER?

In a properly designed vortex, some water molecules dissociate into hydrogen and oxygen. This newly created oxygen and any oxygen already dissolved in the water is mixed up uniformly. Oxygen itself is a hydrophilic element. Hexagonal sheets of structured water grow outward from the oxygen, layer by layer.

4.4.3 STRUCTURING WATER AFFECT PURITY AND PH

Farmers and ranchers have long known of the positive effects of rainwater on their fields. Structured water is one of the most pure water system available. **It creates the same revitalizing effect the earth's atmosphere has on rainwater. When it rains, some of the molecules of water (H2O) are changed into natural peroxide (H2O2), hydronium (H3O) and ozone (O3). Peroxide is water with an extra oxygen atom attached to it.**

Hydronium is water that has an extra hydrogen atom attached to it and ozone is an oxygen molecule with an extra oxygen atom attached to it.

Although rarely discussed in the general or scientific literature, it is the presence of "hydrogen," that is the real determinant of cellular pH, also known as the acid/alkaline balance, a vital component in the health of all plants, animals and people everywhere on the earth. In addition, the extra supply of hydrogen ions attract vital, life-restoring and life-sustaining energy and information from the natural environment, with the bulk water (H2O) acting, in effect, like a "carrier wave."

Ozone is one of nature's greatest cleansers and sanitizers that de-activates bacteria and viruses 3125 times faster and 50% more efficiently than chlorine. This allows for the control of common bacteria like E. coli, as well as fecal coliforms, viruses, fungi, mold, mildew and cysts. Unlike chlo-

146 https://www.vibrancywater.ca/index_files/structured_water_unit_About_Structured_Water.htm

rine, however, which produces trihalomethane (a toxic chemical by-product), ozone is not carcinogenic. In fact, it is extremely beneficial.

While ozone cleanses structured water, the crystalline structures formed in structured water act as “exclusionary zones” for even the smallest molecules of contaminants like chlorine and fluoride. Since these larger contaminant molecules are excluded from the structured water that easily passes through cellular membranes, these contaminants can be eliminated from the body in the bulk water that is not structured.[147]

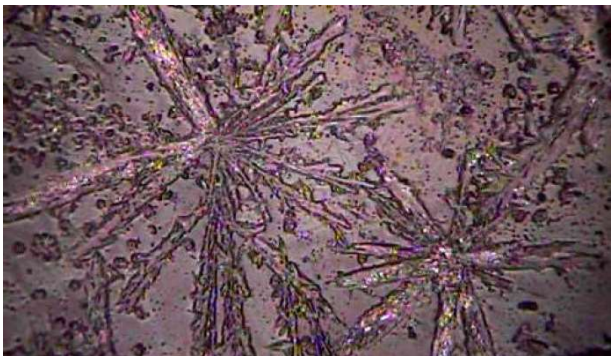


Figure 41: Sample of structured water magnified 400x
Arlis hispania s.l, Crystallization analysis quality of water from purification units evaluation,20 march 2012

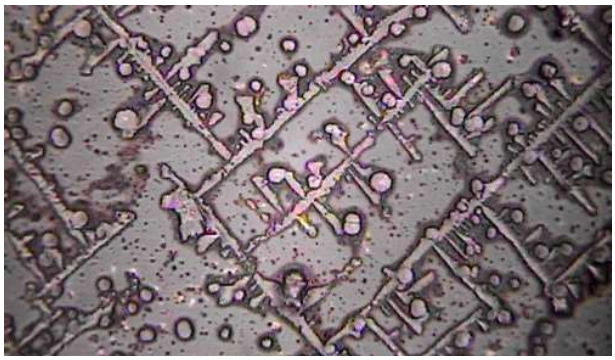
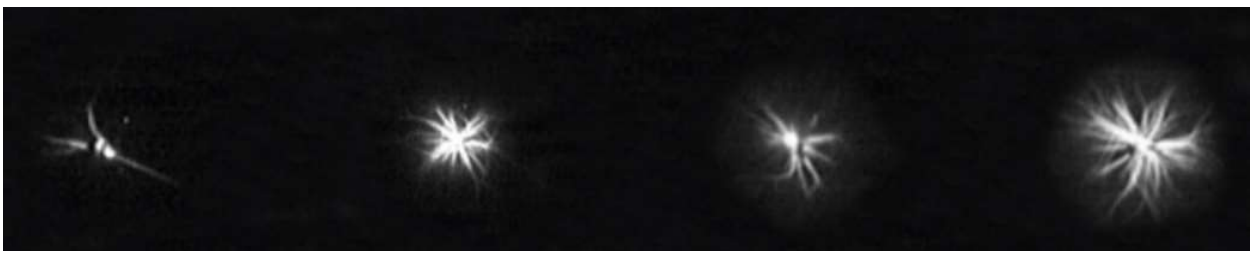


Figure 42: Neutral sample bottighofen. Magnified 400x
Arlis hispania s.l, Crystallization analysis quality of water from purification units evaluation,20 march 2012

Structured Water units raise the pH to 7.0-7.5, the balanced hydrogen potential for a long healthy life. Deionized water and even bottled water has a pH of around 5.5-6.5. The long term effect of this acidic water is that it causes the buildup of free radicals in the body, which are the source of aging, cancer and the destruction of healthy cells. Not only can most filter systems remove almost everything from water, they also remove water’s aliveness, leaving one with essentially ‘dead’ water. Structured Water Units softens water while leaving in all the healthful minerals standard water softeners and reverse osmosis systems remove.

4.4.4 MEASURING THE ENERGY OF WATER

“GDV” or Gas Discharge Visualization is a collection of photographic processes used to capture images of electrical discharges. Through this process we’re able to measure variances of everyday substances, such as water. GDV is a pathway to measuring how much “E” is found in a given type of water.



Tap water
before structuring

Tap water
after structuring

Rainwater
before structuring

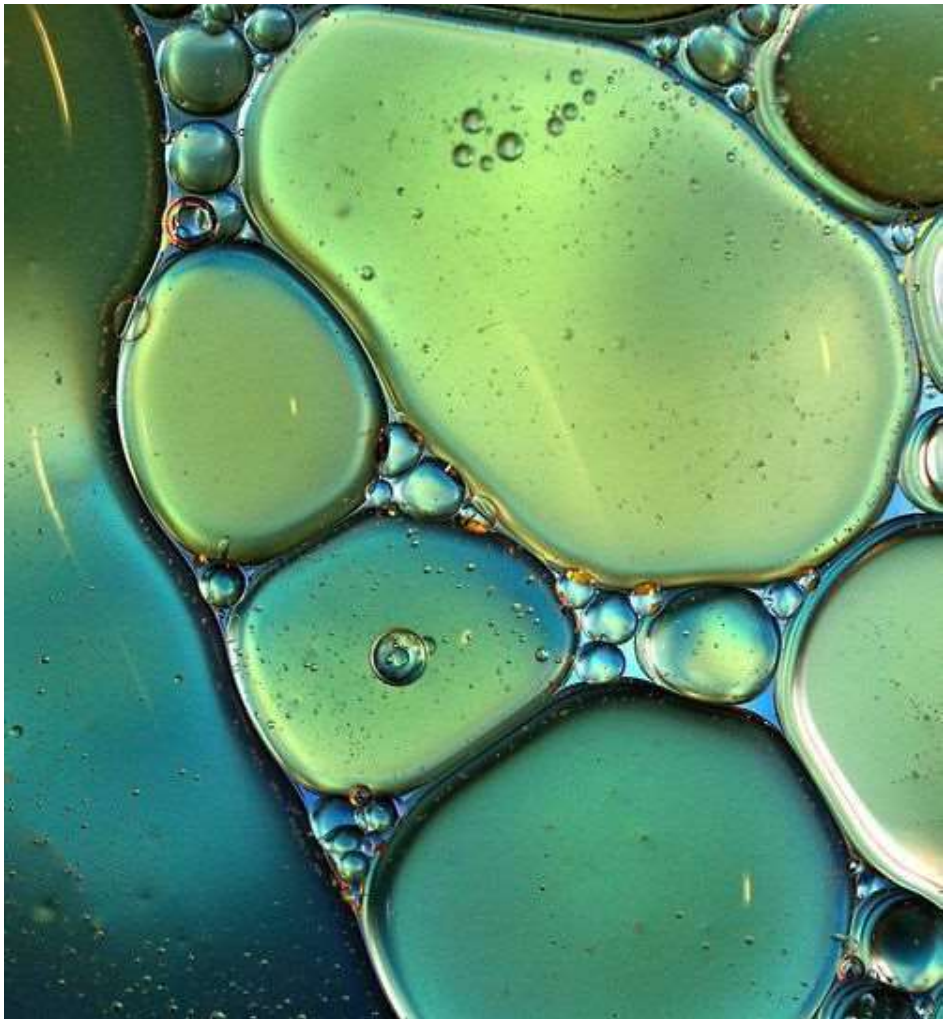
Rainwater
after structuring

147 Arlis hispania s.l, Crystallization analysis quality of water from purification units evaluation,20 march 2012

Dr. Marcel Vogel was a top research scientist for 27 years for IBM. His life's passion was expressed through the use of scientific instruments. He spent over 1 year of his life focused on experiments to determine or deny the existence of Structured Water. Using Ultra Violet Spectral Photometry he concluded:

- evidence of structuring in the form of visual bands in the range of 3000-4000 angstrom units
- Structured Water is different than bulk water including that it stores energy
- one drop of Structured Water raises the energy level of a container of liquid instantly
- when water molecules link up in structure, they form a consciousness which is to say that water molecules organize themselves and store information
- water is the future of medicine as it can be programmed to have desired health giving energies

5 CASE STUDIES



5. CASE STUDIES

In this chapter I have tried to collect some case studies that are projects or products that purify water in a sustainable way. These case studies are divided into four groups:

1. The cases with vortex technology for purified water

2. Products that collect water from the environment such as fog and dew or produce distilled water with solar energy

3. Rainwater harvesting projects

4. This category deals with innovative and sustainable water purification methods used today.





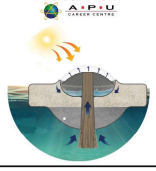
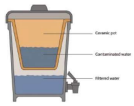




alive water WORLD LIVING WATER SYSTEMS LTD 	World Living Water Systems Ltd.'s headquarters and distribution center is located in North Vancouver, British Columbia. This company produces The Vortex Water Revitalizer™ – a evolutionary concept in water treatment.The Vortex Water Revitalizer™ puts the ordinary tap water through a vortexing motion that causes its implosion. www.alivewater.ca 1127 Crestline Road West Vancouver, BC V7S 2E3 Canada
VortexPower Mein Wasser. Mein Leben.  VortexPower SPRING	The drinking water vortex VortexPower SPRING® with the patented high-speed vortex technology enriches water with oxygen and improves the absorption of water in the body. The SPRING® revitalizes conventional tap water based on nature's example - the whirling aligns the structure of the water in a natural way (hexagonal) and enriches it with energy and oxygen, just like nature shows us in a powerful mountain stream. www.vortexpower.ch VortexPower ® AG Im Tiergärtli 36 8124 Maur Switzerland
FISCHER Wirbelwasser® 	The Original-Martin-Wasserwirbler provides tap water with the original whirling motion, that can find in naturally flowing rivers and streams. It can be fixed to the tap or shower, or to a flexible hose for use as a handshower. www.wasserwirbler.de wasserwirbler.business.site Am Hinteren Feld 13 29683 Bad Fallingbostel Germany
watreco 	The Watreco IVG is working according to Vortex Process Technology, VPT, which is based on the change that occurs when water passes through a vortex generator and is subjected to a strong vortex motion. www.watreco.com Kullavägen 15 232 51 Åkarp, Sweden
Fractal Water Vortex Magnetic System 	The vortex created feels silky and smooth and is of the highest quality. The water reacts to the touch because of the nature of the vortex energy created. This silky smooth, structured water passes through the magnetic array of 8 specially designed high flux density magnets, which are properly magnetically shielded to created a powerful mono-polar effect. www.fractalwater.com Fractal Water, LLC. P.O. BOX 71 Harwinton, CT 06791, United States
Wirbelino  	Wirbelino water whirler is an adapter with two threads and a narrow passage in the middle. When the water is poured from one bottle into another, a natural vortex with suction power is created, which energetically activates and vitalizes the water, physically speaking: restructures and organizes it. www.wirbelino.ch Gartenstrasse 5 CH-9442 Berneck Switzerland
AQUADEA® 	Due to their construction, the crystal vortex chambers suck the water upwards with air. At the beginning, two mutually accelerating primary vortices are created, which become narrower and narrower as they go up. They meet at their zero point at maximum speed. There, the water clusters "crunch" and the H2O molecules that have accumulated are dissolved. www.aquadea.de Hirschbergstraße 14, 85254 Sulzemoos, Germany
RMS RAINWATER MANAGEMENT SOLUTIONS  Wisy vortex rainwater filter	RMS has adopted WISY's 4 step system. The 4-Step System will minimize system maintenance and create a higher water quality for rainwater harvesting system. By using pre-tank filtration, rainwater should be both filtered and aerated. Filtration removes large particulate matter, which frequently both carries and feeds bacteria. rainwatermanagement.com 2550 Shenandoah Ave. NW Roanoke, Virginia 24017 United States

Biodynamizer Dynamizer	The dynamization of water by the Biodynamizer® is done by applying the following 3 principles of dynamization: -the very fast swirling motion of vortices, -the emission of magnetic fields, -the transmission of natural mineral frequencies www.biodynamizer.com Sentier Muraes 10 1440 Braine le Château Belgium
aqualonis	Wind drives the fog into the vertically suspended nets. The droplets are caught in the 3D mesh and merge into larger drops, which then fall into the collecting trough below. From there the fog water is piped into a reservoir. www.aqualonis.com Westendstraße 147 80339 München Germany
Watercone	The Watercone® is a solar powered water desalinator that takes salt or brackish water and generates freshwater. It is simple to use, lightweight and mobile. The technology is simple in design and use and is discribed by simple pictograms. www.watercone.com Gysslingstrasse 71 D-80805 München (Munich) Germany
Eliodomestico	Eliodomestico is a solar-powered water filter that can be made from simple and readily available materials and is capable of purifying 5 liters of water each day. the water filter is essentially a solar still that boils water and separates it from other elements and delivers clean and pure drinking water. www.gabrielediamanti.com/projects/eliodomestico
Innovative Water Technologies rethinking water	SunSpring Hybrid is a Portable Solar and Wind Powered, Self-Contained Microbiological Water Purification System capable of producing up to and exceeding 20,000 liters per day. www.innovativeh2o.com 29625 Industrial Park Road Rocky Ford, CO 81067 United States
SUNGLACIER	The Desert Twins contains two units inspired by the Moon Landers spacecraft. The one twin is the water maker that uses energy to cool down a metal plate. The second contains the energy unit and stores the solar power. www.sunglaciertech.com www.apverheggen.nl Ringdijk 398c 2983 GS Ridderkerk The Netherlands
Ultrasonic Desalination	The ultrasonic mist makers generate salty mist (fog) in the Ultrasonic Box and then taken to the solar still chamber through a flexible duct. An ARMAX glass panel convert the mist into vapor. Then vapor condenses after it makes contact with the sloped glass panel, and due to the panel's inclination, the freshwater condense will slide down until it is contained inside the Double Slope Trough and to the freshwater tank. Team members: Baha Alshwaiki, Anas Ghannam, Omar Ghannam, Louai Maghrabi University of Sharjah United Arab Emirates
C-WATER	'c-water' by chao gao from china, it evaporates sewage, salt water and other watery objects by the use of heat, which is generated from sunlight. it is applicable to wetlands, beaches, boats, sewage and other places. it has a flexible and compactable design. by chao gao China
Air-Extractor	The fan absorbs the water vapour from air via solar power, then the condensation system starts generating water. The other two fans are for heat dissipation. The whole design manifests the combination between technical and environmental resource. 中国美术学院 China Academy of Art China

Warka Water every drop counts 	Warka Tower is designed to harvest potable water from the atmosphere (it collects rain, harvests fog and dew). It functions only by natural phenomena such us gravity, condensation & evaporation and doesn't require electrical power. www.warkawater.org Via Trieste, 01020 Bomarzo VT Italy
WATERHALL OOA ORIENT OCCIDENT ATELIER 	In the WaterHall Project. Water is collected from both natural rainfall and the nearby lake which is then filtered through the system, providing safe potable water for locals to collect and use. With the villagers able to use locally made ceramic jugs and bottles to carry filtered water, the plastic bottle garbage pollution problem is then mitigated. www.ooa.design/en/ 1504, Kwan Chart Tower, 6 Tonnochy Rd, Wan Chai, Hong Kong
BMDesign 	Iran-based BMDesign Studios has unveiled Concave Roof, a double-roof system with steep slopes resembling a bowl for the purpose of rainwater collection in arid climates like Iran, where a lack of water could lead to mass displacement in the future www.bmdesignstudios.com No 419 ASP Towers Kordestan HW,Tehran, Iran
raintap 	The Raintap collects and activates the use of rainwater. Raintap demonstrates how valuable rainwater is, and how we can start making more sustainable water choices The tap(s), footpump and sink make it a clever water station and transform it from a rain barrel, to a (hand)washing station, to a compact outdoor kitchen. www.raintap.eu Statenlaan 8 6828 WE Arnhem The Netherlands
+ART Watershed Core 	Artist Mary Mattingly has designed a sphere filled with native plants that filter water in a gravity-fed system to mimic New York City's water system. Rainwater is collected by the sculpture, where it is cleaned by the filtration elements of plants, soil, sand, rock and a layer of carbon through a process called phytoremediation. www.moreart.org 71 Nassau Street 13A New York, NY 10038
Portable Solar Distiller 	The contraption harnesses the same water cycle of evaporation, condensation and precipitation that nature uses to make rain. The design is adaptable to local surroundings and available resources," he adds. The prefabricated model consists of a plastic canopy to hold the water, an internal funnel to collect the liquid and a bamboo support structure. Designed by Henry Glogau
DIY algae UCL Institute of Education 	Bio-ID Lab designs DIY algae-infused tiles that can extract toxic dyes from water. The structure is designed to hold algae-laden hydrogel for cleaning heavy materials from wastewater.Inspired by the architecture of a leaf, water flows over a series of vein-like channels containing algae prepared in a seaweed-based hydrogel. Pollutants such as cadmium are sequestered by the algae and the hydrogel can then be processed to recover heavy metals safely. www.ucl.ac.uk
Floating Desalination BART//BRATKE 	Foram aims to desalinate sea water while providing a structure to educate people about water shortages. The raft is covered by an organic-shaped roof made of a conduit system that transports water from the sea to desalination tanks, and then into clean water storage tanks.Similar to the raft plan in shape, the roof is rotated to allow for the collection of sea water in the spaces between the raft's three prongs. www.bartbratke.com/ Bergmannstrasse Berlin, 10961
WATERFULL DEW & RAIN COLLECTOR 	WATERFULL is 3 meters in diameter, can collect up to 3.5 liters of water a day in the dry season. In the rainy season the water container allows the accumulation of up to 460 liters of water. The draining water passes through a filter as it enters the container. The tap at the base of the container enables the use of the accumulated water for various home applications Designed by Adital Ela from Israel

LifeStraw® by VESTERGAARD 	LifeStraw's membrane microfilters are made of hollow fiber membrane technology – a similar technology used in kidney dialysis. These membranes are made of small straws that contain microscopic pores of 0.2 microns in diameter. Dirty water enters one side of the straws and clean water passes through the pores while bacteria, parasites, microplastics, dirt, silt, sand and cloudiness are blocked and unable to pass through. https://eu.lifestraw.com/ 333 W Ostend St, Baltimore, MD 21230
Universidad Autónoma de San Luis Potosí VITAL 	Vital is a water filtration system that incorporates a solid and bacteria/virus filter. The low-cost ceramic filter made of a mixture of terracotta, nopal, activated carbon, and colloidal silver that avoids bacteria´s reproduction and filters up to 1,000 liters of clean water. It works as simple as a syringe, absorbing dirty water filtering it up to 98%. Vital, filters, collects, stores and transports water that grows according to your needs from 500 ml up to 1000 ml capacity. www.uaslp.mx Alvaro Obregon 64, Centro, 78300 San Luis, S.L.P., Messico
WaterPod 	WaterPod is a sustainable desalination pod that works on solar distillation to convert seawater into drinkable water. By utilizing natural resources, WaterPod is designed to be placed on the sea for the sea nomads to have access on drinking water easily. www.apu.edu.my Asia Pacific Institute of Information Technology Malaysia
POTTERS FOR PEACE CERAMISTAS POR LA PAZ 	The colloidal silver-enhanced ceramic water purifier (CWP) is a simple, pressed bucket shape 11 in. wide by 10 in. deep, made with a mix of local terra-cotta clay and sawdust . After firing to about 860°c. the filter is coated with colloidal silver. The combination of fine pore size, resulting from milled, screened materials, and the bactericidal properties of colloidal silver produce an effective filter. www.pottersforpeace.org Dodgeville, WI 53533 United States
Aquatabs water purification tablets 	Aquatabs are effervescent tablets which kill microorganisms in water to prevent cholera, typhoid,dysentery and other water borne diseases Aquatabs are used both in emergency situations and also for continuous use in households that do not have access to safe drinking water. www.aquatabs.com Clonard Road, Wexford, Ireland, Y35Y7WY
JERRY  TU Delft	The Jerry Can Water Filter is an easy to use product that helps to decontaminate collected water in developing countries. Its three filters remove chemicals, dirt and 99.99% of bacteria and parasites from the water, resulting in clean and safe drinking water. www.tudelft.nl Delft University of Technology Netherlands
Bottlelight 	The 'bottlelight' provides two essential must-haves: fresh water and light to campers and trekkers who have run out of supplies. in 60 seconds, the UV LEDs eliminate 99.9% of bacteria, viruses and protozoa in 1 litre of water. a USB port can charge the battery – for around 10 hrs/30 lumens – while the 45° reflector at the bottom provides a plain and glare-free light source – making the device perfect for use at night. www.christophkuppert.com Designed by christoph kuppert and helena wendt
Ocean Rescue 	Ocean Rescue provides distilled water made by itself. It will help victims (lost at sea to) survive until rescue. Location information is important for victims to be rescued quickly. Ocean rescue informs its position by emitting light at night and colorful smoke during the day. Location information is transmitted from the time . Designed by Seol-Hee Sohn, Seung-Hyun Yoon and Cheol-Yeon Cho
Graphair CSIRO 	The system employs a film made from a thin layer of graphene, called Graphair, which allows water to pass through microscopic nanochannels in its surface while stopping pollutants with larger molecules.They clog or allow contaminants to pass through, so they have to be separated out before the water is filtered. This technology can create clean drinking water, regardless of how dirty it is, in a single step. www.research.csiro.au

In this section, I have tried to review and analyze the 7 cases that have been of most interest for me.

5.1 WISY VORTEX RAINWATER FILTER

A rainwater filter is the key to keeping rainwater harvest clean and free of debris. Without rainwater water filters, the collected rainwater could be contaminated with harmful organic material and other sediments suspended in the water. This filter type, including in-line, vortex, and horizontal.

RMS has adopted WISY's 4 step system. The 4-Step System will minimize system maintenance and create a higher water quality for rainwater harvesting system. By using pre-tank filtration,rainwater should be both filtered and aerated. Filtration removes large particulate matter, which frequently both carries and feeds bacteria. Removal of this particulate matter, along with oxygenation of the water, greatly reduces the amount of harmful bacteria in the tank.

5.1.1 HISTORY

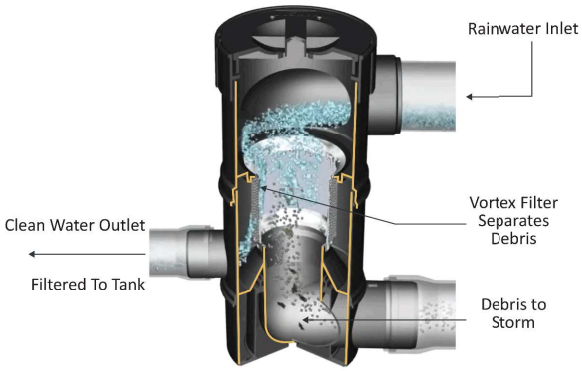
In 2000, David Crawford put his 22 years of experience into a new company he named Rain Water System, Inc. His vision was to form a company that would address rainwater conservation and management as well as sustainable water applications and practices. Today that company(now known as Rainwater Management Solutions) provides design, consulting, and engineering solutions for rainwater and stormwater management to commercial and residential developers, engineering and architectural firms, and professionals in the agricultural field.

5.1.2 DETAILS AND MATERIALS

Step 1:PRE-TANK FILTRATION

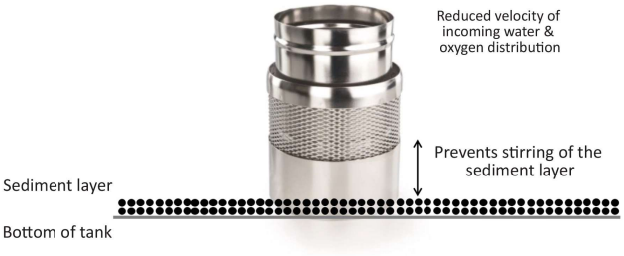
During the first step of the filtration process up to 90% of rainwater is filtered & diverted to the rainwater tank. the remaining 10% are used to ensure the self-cleaning effect of the filter. WISY filters operate as a first flush device. directing leaves, dirt& debris to drainge or on-site Detentiortank(OSD). Therefore, large particulates are removed. Due to the oxygenation of the water duringthe filtration process, the amount of harmful bacteria in the rainwater tank is greatly redouce.

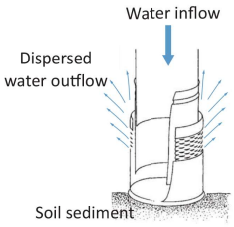
- There is a vast range in terms of collection area for the rain water filters running anywhere from 45 Sq. m. to 3000 Sq. m.
- There is also a range of micron size options for rain water filter products, and the micron sizes range from 280 to 900 microns.
- For the different inlet size of rainwater filter, there are including 4, 6, and 12-inch(10,15 and 30 cm) size options.
- Install Above or Below-ground



Step 2:SMOOTHING INLET

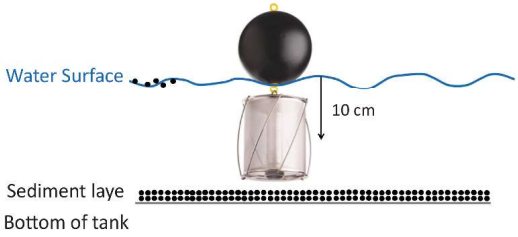
The smoothing inlet is an all stainless steel device that fits on the 4” or 6” inlet pipe in the storage tank.It is used to prevent the agitation of sediment at the rainwater inlet into the storage tank. The smoothing inlet also helps aerate the water as it enters the tank and should rest on the bottom of the tank.





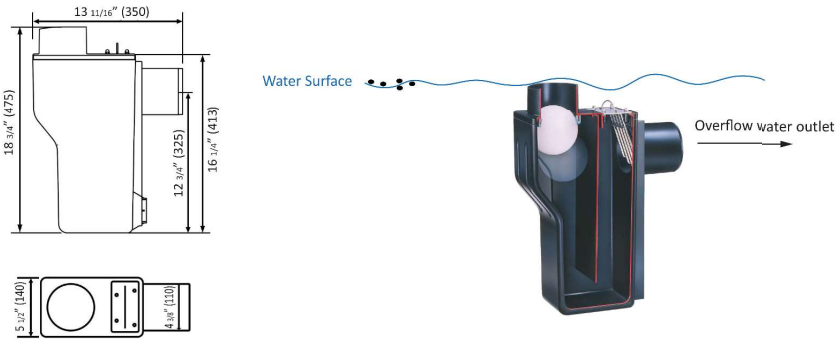
Step 3: FLOATING FILTER

The Floating Filter consists of a polyethylene ball and stainless steel filter and is supplied with a standard 7 ft. length of food-grade suction hose. The nozzle connections are available in 1/4” and 2” sizes. The filter is available separately or as part of a kit for both submersible and booster pumps. Hose lengths greater than 7 feet are available through RMS.

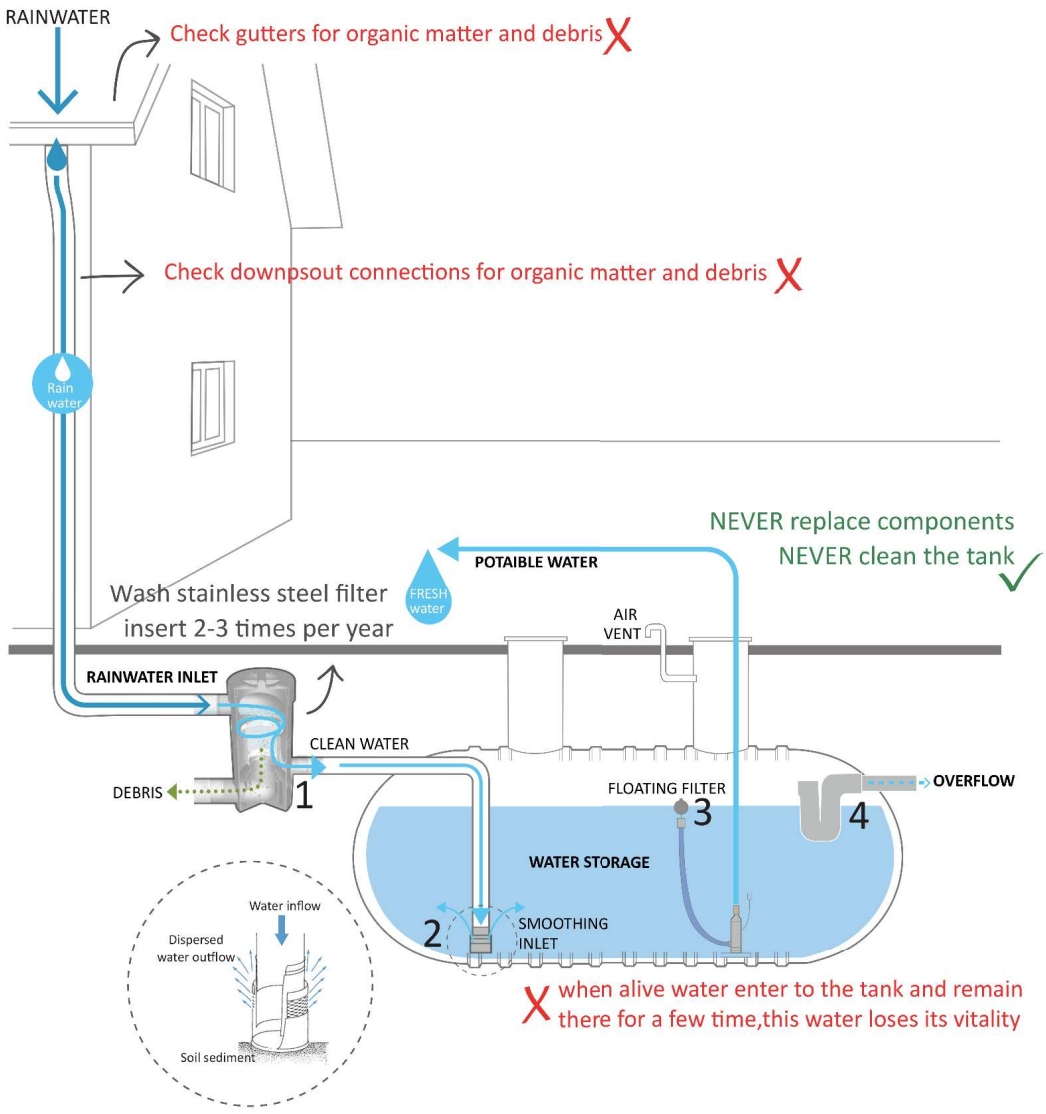


Step 4: OVERFLOW DEVICE

The 4” WISY Multi-function Overflow Device is connected to the overflow pipe within the storage container or cistern. The multi-functional overflow device is made of impact-resistant ABS plastic that eliminates drain odors in the tank, provides vermin and backflow protection, and skims surface debris. Device comes with support strut, clamp, and fits 4” overflow piping.



5.1.3 FUNCTION



5.1.4 ADVANTAGES OF PRE-TANK FILTRATION

- Dual intensity filter works on the principle of cohesive and centrigugal force.
- Removes Rooftop Debris
- Works on gravitation force(No external energy required)
- Cost effective and affordable.
- Compact in size and wall mounted.
- Inbuilt self-cleaning mechanism.
- Low Maintenance Filter.
- No consumables required.
- Flexibility in pipe connection to any angle and degree.
- Oxygenates Water.

5.1.5 Availability

Publicly available: Yes

Countries where available: United States(Origin Country)

Price range (USD): $2250 (2,100 Square Foot Underground Rain Water Harvesting Kit)

5.1.6 ANALYSIS

Sustainable development	✓
Simple construction	X
No electricity	✓
Local materials	X
Easy maintenance	X
Deployable	X
Low-cost	X

Social manufacturing	X Fabricated
Community gathering	X This is designed for the single users
Economic grows	✓

Significant savings are made on bottled water purchases. Indeed tap water (which will be filtered & energized) costs 180 times less (~ € 0.004/L) than bottled mineral water (~ € 0.75/L)! With this argument, by replacing the bottles with the Biofiltre + Biodynamizer® package, a family of 4 people will save more than € 1,000/year). These devices are therefore reimbursed in less than 3 years.

5.2 Vortex Power

The **VortexPower Spring®** is a bio-physical functioning product for the refinement of drinking water. Water is revitalized and charged with additional oxygen, as occurs in nature, by means of the regeneration of water through the whirling of water into vortices.

Hydrovortexer is used to transform the water that flows in the homes into oxygen-rich, vitalized and therefore healthier water. In other words, it regenerates it, as if it were spring water, because this precious element loses its energy as it flows imprisoned in pipes and conduits.

It is made in Switzerland and was awarded the coveted “Red Dot Design Award “ in 2012. It costs 496 francs , 50 times more than a normal aerator tap water.

5.2.1 History

In 2010, the German water fanatic and sales professional Matthias Mend, who lives in Zurich, approached Alexander Class with the idea of founding a company for water treatment products, which should develop innovative products of the finest quality based on his knowledge.

In 2011 they came onto the market with their first product, the VortexPower SPRING water whirler, which was designed with a completely organic shape for the first time.

5.2.2 MATERIALS & DETAILS

The **VortexPower SPRING** consists of stainless steel optimized in long research series, it is currently the optimum for water swirlers.

The VortexPower SPRING is manufactured by the Swiss precision turning workshop Künzli AG in Wangen.

Technical data:

Height: 38 mm, diameter: 31 mm, weight: approx. 90 g

Spring connection thread: M22x1 mm inside

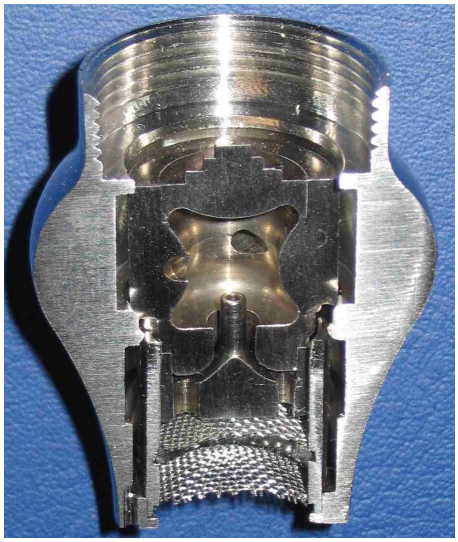
Connection thread with adapter: M24x1 mm outside

Material: nickel-free stainless steel with food

Approval Minimum operating pressure: 2.5 bar, maximum: 6 bar

Maximum water temperature: 95° Celsius

Flow rate: approx. 3- 7 liters per minute



Not Organic elements in SPRING stainless steel:

Chromium, it is an essential trace element for all living things and which even supports the natural ferrite structure of iron. With a whopping 19%, it is represented in the SPRING stainless steel and ensures high corrosion resistance, especially in contact with chlorinated and hot water.

Molybdenum is used at around 3% in Spring stainless steel.

Titanium, There is 1% in SPRING stainless steel. It helps to stabilize the steel by bonding with the carbon, preventing the protective chromium oxide layer from reacting with the carbon and depleting the iron.

Silicon As an aside, it increases the amount of nitrogen that SPRING stainless steel can hold while helping to reduce its carbon content. Therefore, the silicon content of SPRING stainless steel can be slightly higher than that of other steels.

Organic elements in SPRING stainless steel:

Carbon makes steel harder but also more brittle. IT is content in SPRING stainless steel at less than 0.02%.

Phosphorus, ctually slows down rusting.But from a percentage of more than one. Its share in

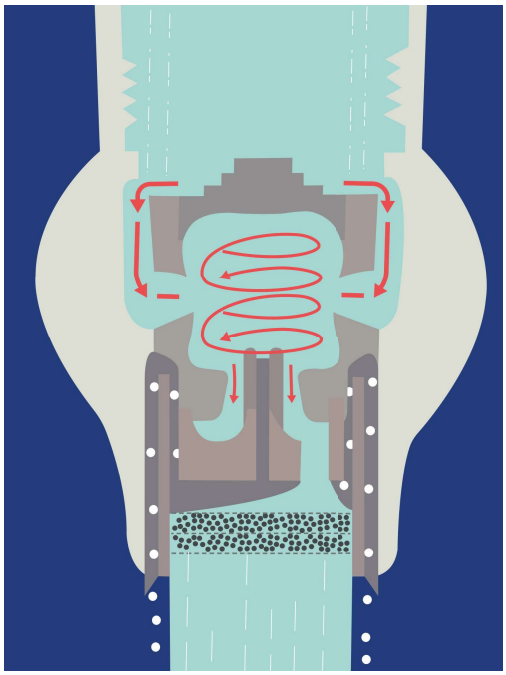
SPRING stainless steel is therefore also less than one percent.

Oxygen The rust resistance of stainless steel consists precisely in the fact that it already has a wafer-thin layer of “rust” on its surface- not iron oxide, but chromium oxide.

Nitrogen As a result, nitrogen drastically improves corrosion resistance - around 20 to 30 times better than chromium.

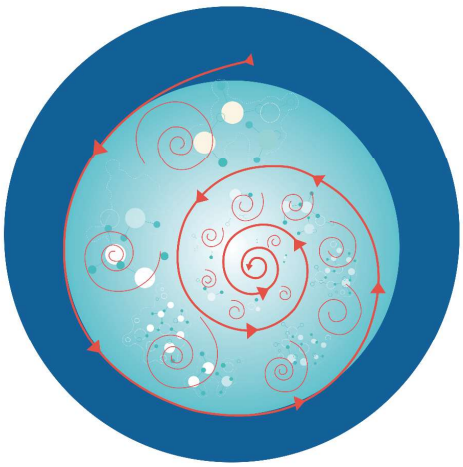
Hydrogen It is Presence of hydrogen as the number one element in SPRING stainless steel extremely important.

5.2.3 FUNCTION



The VortexPower Spring contains organically shaped vortex chambers and two special injection and spray devices to dissolve a large amount of air in the water. The vortex chamber is being filled in a tangential way by three inlet nozzles that are shaped like vortex funnels similar to the ones forming naturally in the kitchen sink or bath tub when leting out the water. That guarantees the water running at high speed and in a whirling way already from the beginning.

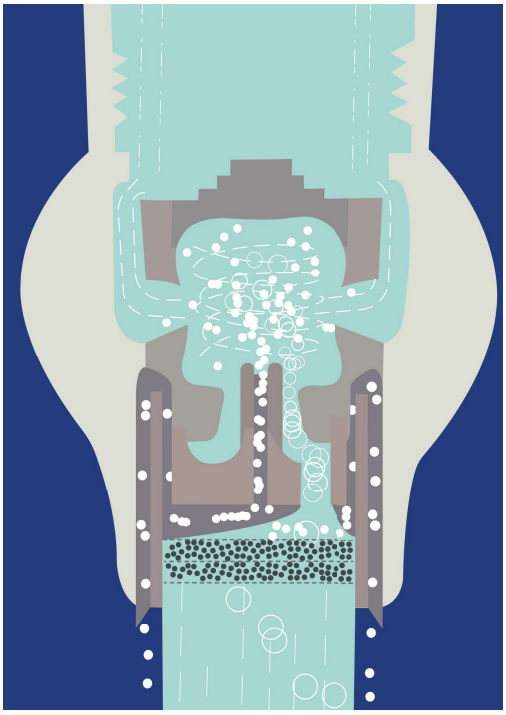
The three water jets from these injection nozzles enter the vortex chamber at the outward edge accelerating the water inside to a spinning movement of complex geometry.



Due to the fact that the water cannot easily flow out through the central hole in the bottom of the vortex chamber, several antagonistic vortices are being formed in a concentric arrangement. They are running upwards and downwards turning clockwise and anticlockwise at the same time creating in between each other a large amount of much smaller secondary vortices which can be called micro-vortices or nano-vortices.

It is them which are responsible for grinding the quasicristalline water structure – clusters consisting of hundreds of H2O-molecules – down to a much smaller size like they normally exist only in hot water. That leads to a much higher flowability and an increased solving capacity of the water even at low temperatures.

The Spring is constructed in such a sophisticated way that despite the water being constantly pressed into the vortex chamber the resulting suction power of the high speed vortices draws air into the water. A constant stream of air is being suckedthrough the circle of small holes at the lower edge of the Spring around the outlet hole. The air is carried on to a small tube ending inside the vortexchamber right in the centre of the main vortex. That leads to a large amount of oxygen being dissolved in the water making it feel and taste like water from a creek high up in the mountains.

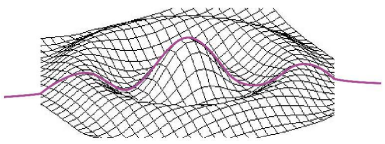


There is always a certain amount of the water in the main vortex chamber that remains in one of the spinning vortices, whereas the other part flows out into a secondary vortex chamber using the high speed of the water to form another vortex. This vortex has the shape of a torus, looking like an apple or a donut. This toroidal vortex is designed to slow down the vigorously flowing water by means of an antagonistic stream of water. This clever way of using water itself to slow down the water harnesses the moving energy of the tap water to a maximum and avoids turbulent flow to prevent damage to the water structure.

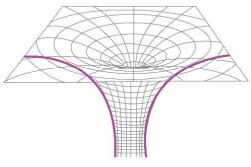
In the end a cycle of holes several water jets flowing against two fine mesh wires. There the water is sprayed into millions of small droplets forcing it to take up even more oxygene from the stream of air that is constantly moving through the Spring.

Better function

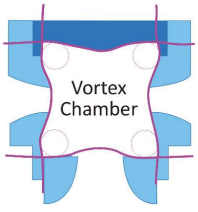
Hyperbolic function

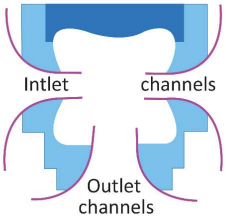


3D-Graph



3D-Graph





5.2.4 ADVANTAGES

Taste: Water tastes softer and more digestible. Therefore, one automatically drinks more. In addition, the minerals in the water will be more easily absorbed into the body.

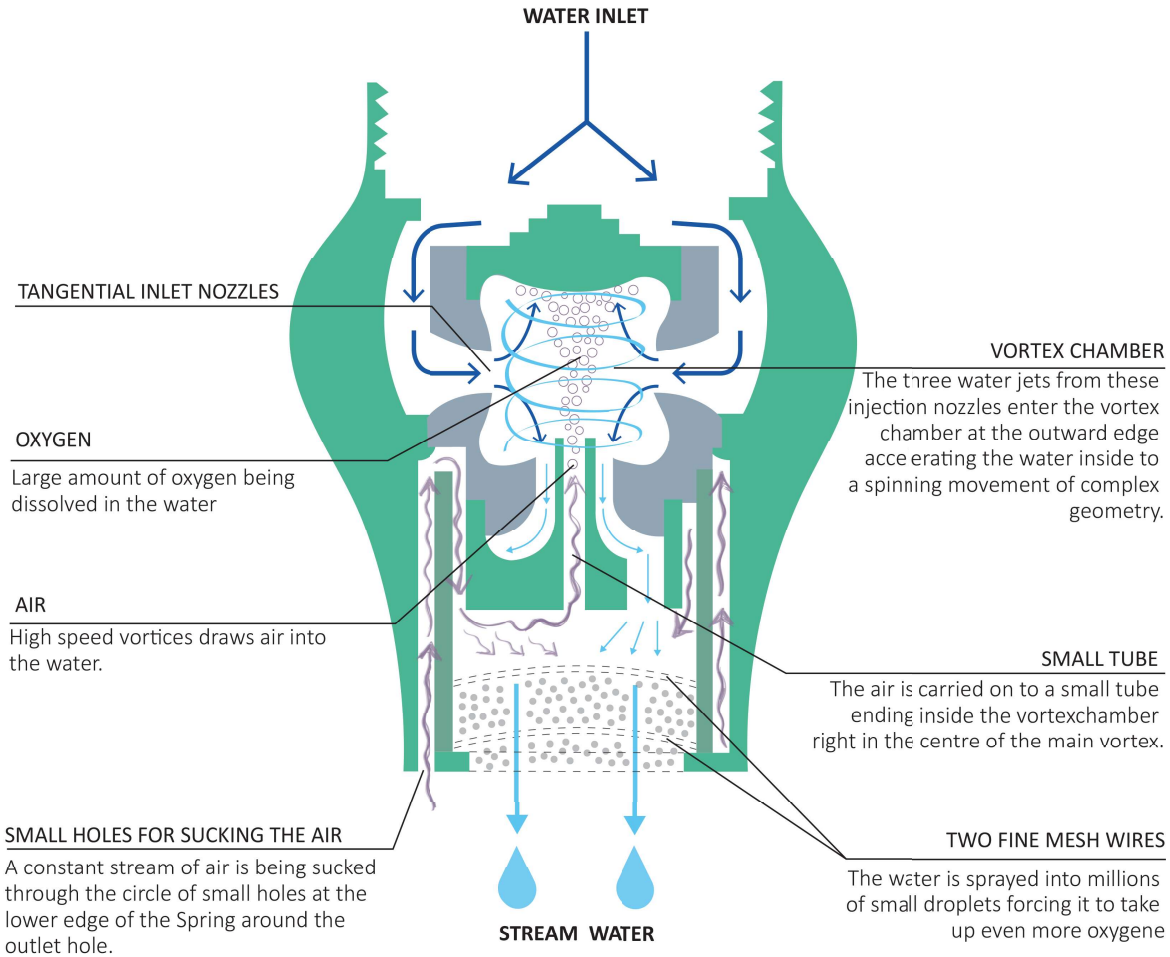
Calcium: There are noticeably fewer and less visible deposits of calcium on dishes and on pans, in which water is cooked. Also, house-hold appliances into which one fills water.

Contamination: Swirling of water can help to make germs harmless for the human body.

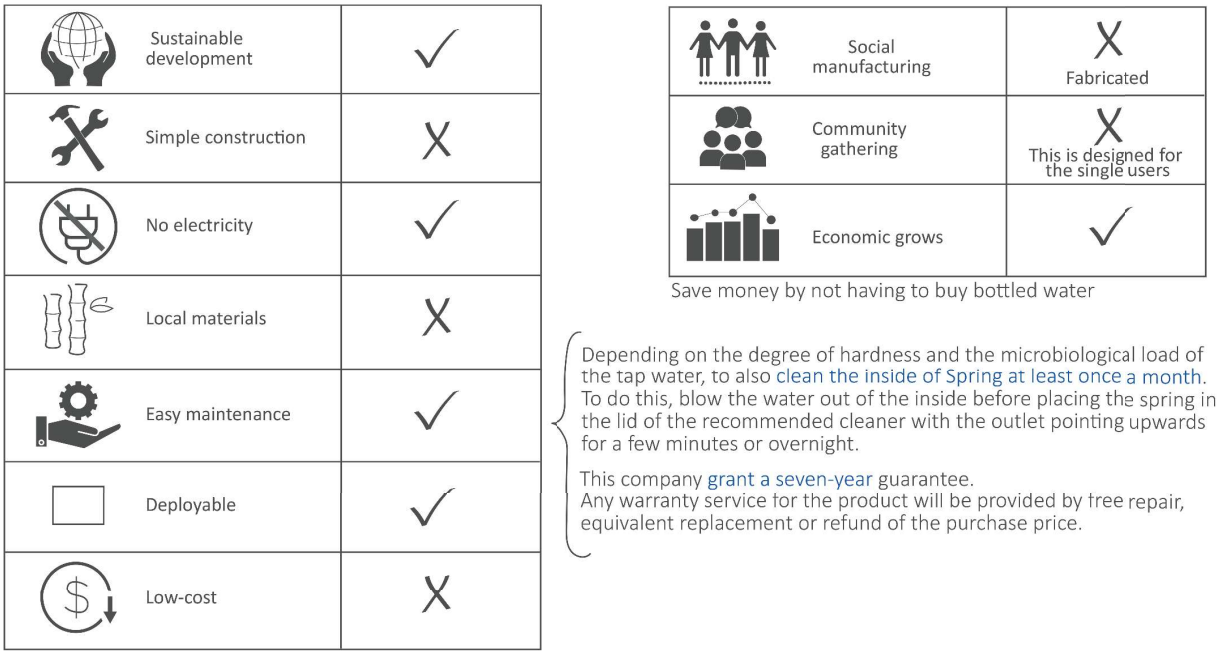
Health: The structure of water is changed in a natural way (hexagonal) by swirling. This water can be much better absorbed by our body-cells. All of the nutrients and minerals in the body can be better bonded and transported. More energy is available to the body, as a result of more rapid expulsion of waste products. This results in higher vitality and performance from the body and spirit.

Energizing: Pure water is the most effective energy source in the world. Swirling water increases its fluidity and solubility and aids the body in all metabolic processes.

5.2.5 DIAGRAM



5.2.6 ANALYSIS



5.2.7 AVAILABILITY

Publicly available: Yes

Countries where available: Switzerland(origin country), Germany, Austria, Norway, Sweden, Czech Republic

Price range : 620 CHF (625 EUR)

5.3 ALIVE WATER

World Living Water Systems Ltd.'s headquarters and distribution center is located in North Vancouver, British Columbia. This company produces The Vortex Water Revitalizer™ – for water treatment.

Figure 43: Vortex Water Revitaliser (cut-open to show twin spirals inside)

The full product line of Vortex Water have an internal double spiral flow form that simulates the natural movement of water in nature, like that of a river or stream; creating a powerful vortexing action in the water. This vortexing movement is found throughout nature in rivers, streams and oceans.

5.3.1 HISTORY & DEVELOPMENT

Mikael Lund, the founder of World Living Water Systems Ltd., designed The Vortex Water Revitalizer™ in 2003, inspired by the lifelong work of Austrian forester, inventor, and philosopher Viktor Schauberger, over 15,000 units sold worldwide. Mikael; through study of Viktor's research notes understood that our water today is basically dead but it could still be rejuvenated, refreshed, revitalised and reinvigorated using Viktor's theories.

5.3.2 PRODUCTS

This company has a various products for treaTIng tap water of household or commercial use.there are three categories of the household use: **Kitchen, Shower and Portable Models**

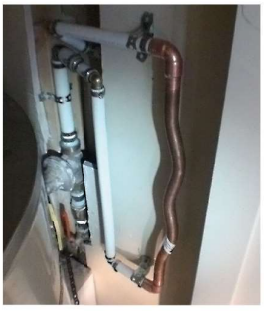
Whole House Models

Filter Models

The **Whole House Vortex** Water Revitalizer is designed to treat water throughout the home. To give the fresh taste and sensation of water.

River of Life Whole House Vortex Water Revitalizer has an internal double spiral flow form that treats the water.
The wavy shape of the pipe adds more flow dynamic, which better simulates the natural movement of water.
Installation is on the main water line of home or business.

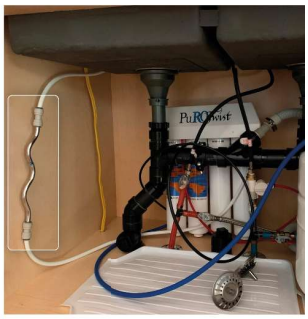
MODELS DIAMETER	1/2"	3/4"	1"
DIMENSIONS	12"L	16"L	24"L
WEIGHT	222g	585g	1,105g
MATERIAL	Copper	Copper	Copper
PRICE	US$ **798**	US$ **998**	US$ **1,498**



The Vortex Water Revitalizers for Filters

This product is Designed to connect to an under or over-the-counter filter, reverse osmosis system, distiller, or other water treatment system, for the Filters will improve the taste, feel quality, and health of treated water.
Installation should always be done after the filter, as the last mode of water treatment.

MODELS DIAMETER	1/4“	3/8“
DIMENSIONS	7“L	3/5“L*3/2“W
WEIGHT	38g	88g
MATERIAL	SS316 Stainless Steel	SS316 Stainless Steel
PRICE	US$ **398**	US$ **298**



Funnel Vortex Revitalizer can be used just like any other funnel. Place the narrow end over a glass or a bottle and pour the liquid into the funnel.
Can be used both funnel models to filter water, as well as any other beverage, including wine.

MODELS	Portable Funnel Standard	Portable Funnel River of Life
DIAMETER	Bottom 1/2", Top of the funnel 3"	Bottom 1/2", Top of the funnel 3"
DIMENSIONS	7"H x 3"W	15"L x 3"W
WEIGHT	218g	357g
MATERIAL	Copper	Copper
PRICE	US$ **498**	US$ **998**

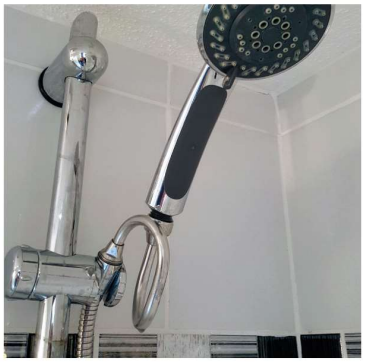
The **Vortex Water Revitalizer** Kitchen, Shower and Portable Models were designed to treat tap water for those living in apartments, condos, rented homes, or travel.

Kitchen Vortex Water Revitalizer is for people that living in apartments or rented homes. This water treatment device needs one simple installation and no maintenance or replacement parts required.

MODEL	Kitchen Revitalizer
DIAMETER	3/8"
DIMENSIONS	5"L x 3.2"W
WEIGHT	160g
MATERIAL	SS316 Stainless Steel
PRICE	US$ **298**

This water treatment revitalizes the water that flows from shower. It’s seen changes in hair and skin quality after a few uses of revitalized water. Installation doesn’t require changing the pipes. No maintenance or replacement parts are needed.

MODEL	Shower of life
DIAMETER	3/8"
DIMENSIONS	3.5"L x 3.2"W
WEIGHT	127g
MATERIAL	SS316 Stainless Steel
PRICE	US$ **298**



5.3.3 MATERIALS & DETAILS

The materials of Vortex Water Revitalizer should be copper and PVC pipes, stainless steel. Vortex Water Revitalizes can be used for iron or stainless steel pipes.

Figure 44: Spinning water in twin spirals, the way healthy DNA does

Figure 45: Section of the pipe (double spiral inside Vortex Water Revitalisers)

5.3.4 FUNCTION

The best energetic charging values for water was found at spiral turns between 28 and 32 cm apart, rotated by 180°, established[148].

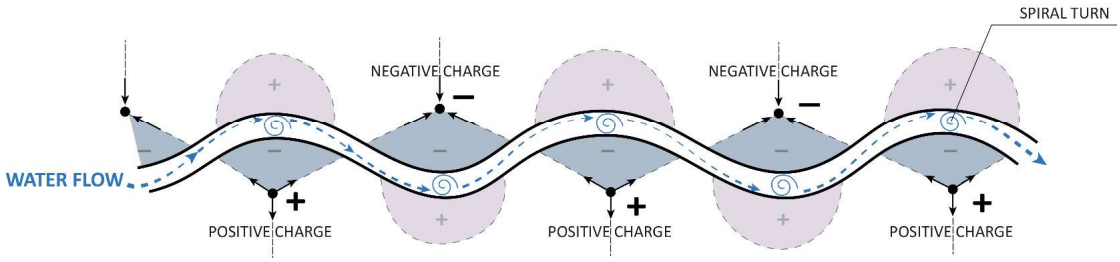


Figure 46: The wavy shape of the pipe adds more flow dynamic, which better simulates the natural movement of water.

It is the electromagnetic system that builds up according to the shape of the respective object, the principle of opposite poles and the associated arrangement of the magnetic fields and the energetic flow lines (fluctuation lines) that are directed accordingly.[149]

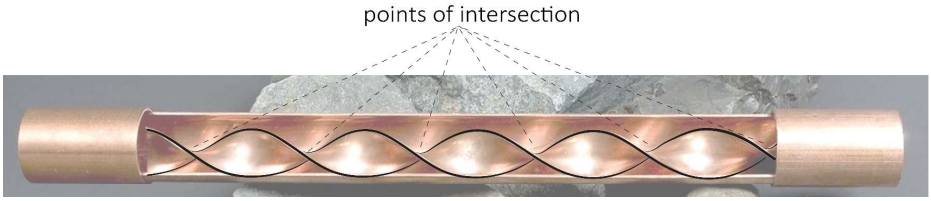
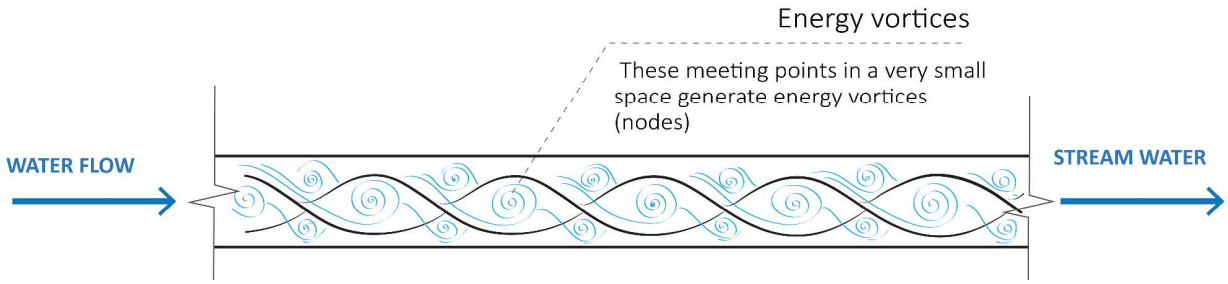


Figure 47: Internal double spiral flow

In this ray system with the more points of intersection of the swing lines there are the more harmonious, tighter the rhythm.

148 Verein für Implosionsforschung,Spiral pipe in accordance with E. Neumann,Klaus Rauber, page:8
149 https://www.implosion-ev.de/pdf/SPR.pdf



5.3.5 ADVANTAGES

This is in sharp contrast to tap water which travels through miles of straight pipes and 90 degree turns, resulting in lifeless low frequency water. This vortexing action causes implosion in the water that positively transform the water:

- Restores the natural structure, health and vitality to water:

- Improves water's hydrating properties
- Increases and activates dissolved oxygen in the water by 22-25%
- Erases harmful frequencies (memory of water)
- Improves water's detoxifying properties
- Increases energy levels in the water
- Micro-clusters the water molecules

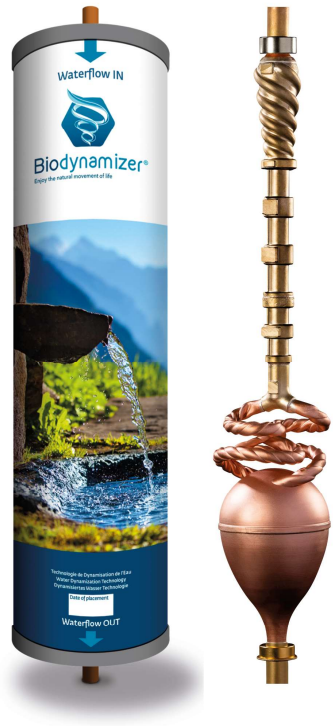
5.3.6 ANALYSIS OF ALIVE WATER

Sustainable development	✓
Simple construction	✓
No electricity	✓
Local materials	X
Easy maintenance	✓
Deployable	✓ Just Funnel Vortex Revitalizer is deployable
Low-cost	X

Social manufacturing	X Fabricated
Community gathering	X This is designed for the single users
Economic grows	X

X There aren't economy because must have a filtration system for household and after that, for having a high quality water install these products. therfore, not all social stratum can participate in spending

5.4 BIODYNAMIZER



This Company Dynamize water, try to restore all of its natural energy and its original structure. The Biodynamizer® is a hydrodynamic device that reproduces the natural cycle of water in an accelerated way by copying its movement as it flows freely in nature. This natural technology can regenerate the water from all the taps in a home to make it comparable to mountain water.

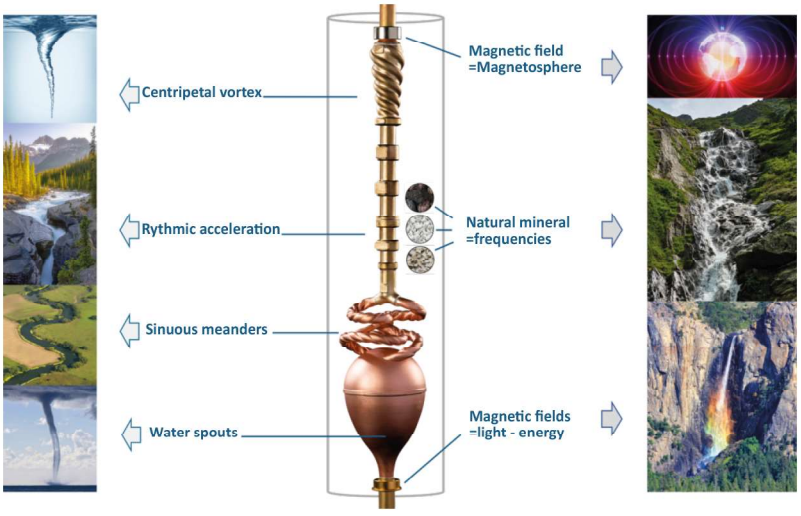
The Swiss water quality specialist, Benoît Saint Girons, who wrote a book on this subject in 2020 qualified the Biodynamizer as “the most efficient water dynamization system on the market” by giving it a rating of 18/20, the highest score! (book written in French: “la qualité de l’eau”)!

5.4.1 HISTORY

Christophe Carrette Naturalist, philosopher and researcher. Since 2014 he has actively participated, with European scientists and researchers, in studies on dynamized water and its benefits. He started to develop Biodynamizer in 2015

Vision of this company is:

- GET INSPIRED: offer the best water filtration and regeneration solutions that draw inspiration from science and nature so that it can regain it’s original qualities for the greater good of all!
- GIVE ACCESS: to those who wish, water equivalent to mountain water and help stop the spread of plastic in nature.
- PARTICIPATE: in a sustainable and ecological economy.
- SHARE: and communicate the findings on water.
- ENCOURAGE: a world more respectful of nature.



5.4.2 FUNCTION

The dynamization of water by the Biodynamizer® is done by applying the following 3 principles of dynamization:

-the very fast swirling motion of vortices,
-the emission of magnetic fields,
-the transmission of natural mineral frequencies

- **The Vortices**

The natural flow of water which is reproduced by the forms of the Biodynamizer® borrows from nature the following movements:

- The Turritelle induces a triple centripetal vortex which accelerates water generating a swirl imitating a tornado.

- The Rhythmic Tube reproduces the dynamics of a mountain waterfall generated by rhythmic recesses in the pipes which give it phases of expansion / contraction, deceleration / acceleration as well as high / low pressures.

- The Serpentine produces a double vortex with an inversion of rotation reproducing the meanders of rivers whose inclined and plane angles induce accelerations – decelerations of water.

- Inside the Egg there is a columnar vortex, a phenomenon where water is extremely accelerated by rotating movements around its own axis. Its speed increases exponentially to reach a climax when the egg is filled with water , Here the water swirls freely with very strong intensity in the center of the egg. Kinetic energy is at its peak there and manifests itself in thousands of vortices which are amplified by the golden ring magnet.

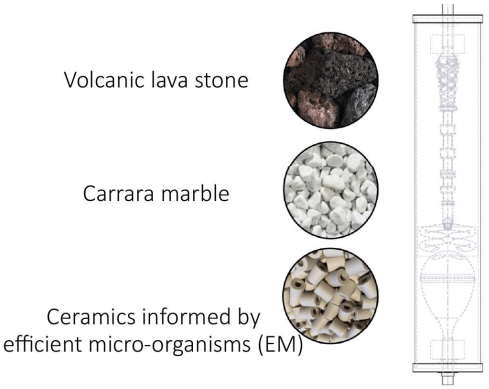
- **MAGNETISM**

Emissions of magnetic fields emitted by 2 natural ring magnets in rare earths, one of which is gold plated with diametral and radial magnetizations (toroidal);

There is a very strong interaction and amplification of energy between the toroidal magnetic field & the columnar vortex of water in the hyperbolic funnel!

- **THE NATURAL MINERAL DYNAMIZATION FREQUENCIES**

Water captures the energies of minerals and noble metals (Carrara Marble, Lava rock, informed Ceramic & Copper, Gold and Silver)



Micro-organisms (EM): Clay mixed with several complementary strains of fermentation bacteria, fungi, and yeasts, existing in their natural state and emiting far infrared waves favorable to life and water (theory of Prof. Dr. Teruo Higa) .

5.4.3 DETAILS

- Dimensions Biodynamizer (cylinder + fittngs): 90 cm x cylinder outer Ø: 160 mm, weight: 17 kg (+ 2,2 L with water in the device)
- 3/4 inch brass fittngs

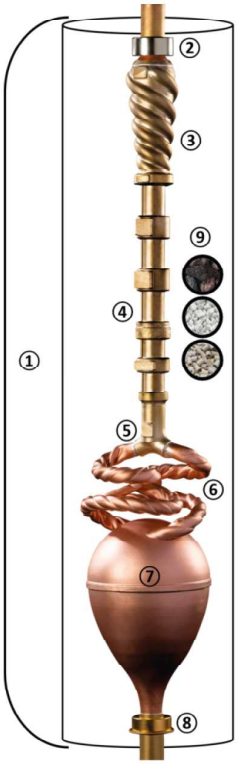
① AQUIFER PART: large amplitude: 897 mm-> gives mechanical velocity to water (kinetic energy): composed of copper & brass & silver (diamagnetic conductive metals).

③ TURITELLE: Vertical centripetal and anti-clockwise vortex, 3 channels with 2 turns; golden ratio proportions.

⑤ T- Form: splitting of the tube inducing an acceleration of the water flow. The shape respects the golden angle.

⑥ SERPENTINE: double vortex (folding / triple threading) with an inclined and horizontal angle slope; anti-clockwise vortex – Rotation reversal – clockwise vortex

⑨ Transmission of natural dynamization frequencies: volcanic lava stone, ceramic informed by Efficient microorganisms (EM), Carrara marble and noble metals (copper, silver and gold)



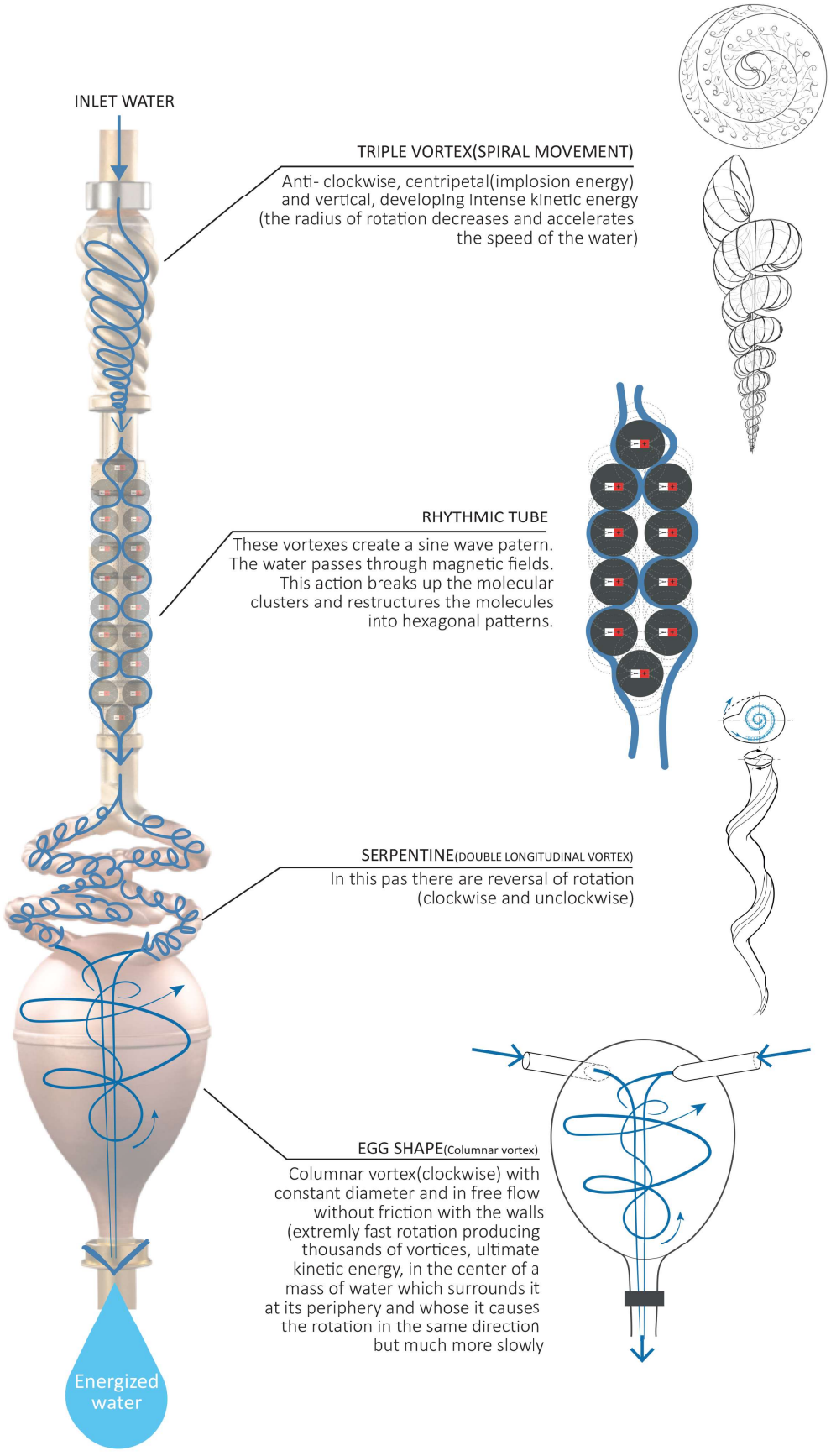
② RING MAGNET NORTH: 1 nickel-plated neodymium magnet, diametrical magnetization.

④ RHYTHMIC TUBE:Rhythmic harmonic pulsations by expansions & contractions, accelerations & decelerations (Venturi effect) of the water flow. The interior cavities are concave to allow the water to ripple.

⑦ EGG: Ovoid matrix ending in hyperbolic funnel generating a clockwise columnar vortex in free flow in its center which induces a very powerful kinetic energy in the heart of the egg; proportions based on a pentagon = Phi = wave shape

⑧ RING MAGNET: 1 gold-plated neodymium ring magnet, toroidal magnetization, S / N orientation; magnet proportions = Phi; Very strong interaction and amplification of energy between the magnetic field & the columnar vortex in the funnel!

5.4.4 FLUXES


INLET WATER
TRIPLE VORTEX(SPIRAL MOVEMENT)
Anti- clockwise, centripetal(implosion energy) and vertical, developing intense kinetic energy (the radius of rotation decreases and accelerates the speed of the water)
RHYTHMIC TUBE
These vortexes create a sine wave patern. The water passes through magnetic fields. This action breaks up the molecular clusters and restructures the molecules into hexagonal patterns.
SERPENTINE(DOUBLE LONGITUDINAL VORTEX)
In this pas there are reversal of rotation (clockwise and unclockwise)
EGG SHAPE(Columnar vortex)
Columnar vortex(clockwise) with constant diameter and in free flow without friction with the walls (extremly fast rotation producing thousands of vortices, ultimate kinetic energy, in the center of a mass of water which surrounds it at its periphery and whose it causes the rotation in the same direction but much more slowly
Energized water

5.4.5 ADVANTAGES

Improves water's hydrating properties.

Increases energy levels in the water

Improves water's detoxifying properties

Erases harmful frequencies (memory of water)

Micro-clusters the water molecules

Increases and activates dissolved oxygen in the water by 22-25%

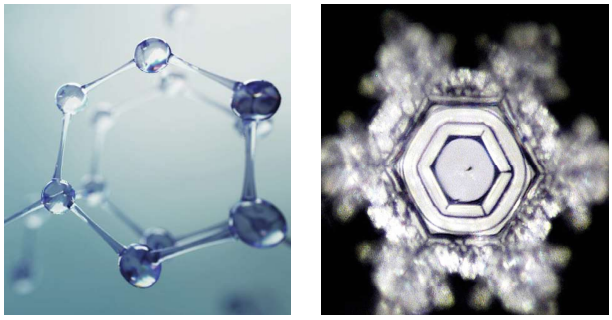


Figure 48: Biodynamized water is water which has a hexagonal structure comparable to that of natural water which springs spontaneously from its source (this restructuring comes from movement & magnetism present in the biodynamizer)

5.4.6 AVAILABITILY

Publicly available: Yes

Countries where available: Belgium(Origin Country), Europe

Price range (EU): 2.800 € + 55 € (Transport EU)...

* Prices may vary by + 10% on export depending on the country of delivery of the devices

5.4.7 ANALYSIS

Sustainable development	✓
Simple construction	X Complicated construction
No electricity	✓
Local materials	X
Easy maintenance	✓
Deployable	X
Low-cost	X everyone can't afford to buy

Social manufacturing	X Fabricated
Community gathering	X This is designed for the single users
Economic grows	✓

Significant savings are made on bottled water purchases. Indeed tap water (which will be filtered & energized) costs 180 times less (~ € 0.004/L) than bottled mineral water (~ € 0.75/L)! With this argument, by replacing the bottles with the Biofiltre + Biodynamizer® package, a family of 4 people will save more than € 1,000/year). These devices are therefore reimbursed in less than 3 years.

5.5 ELIODOMESTICO SOLAR WATER DISTILLER

This project was taken from the Gabriele Diamanti an Italian designer. He has made a solar oven called Eliodomestico that can transform salty water into potable water. 5 litres of salty water can be transformed into potable water daily. There is an urgent need of clean, pure and safe drinking water in many countries.

At the end of the day, the Eliodomestico delivers 5 liters of fresh drinking water. The lower basin is specifically designed for transport on the head.

5.5.1 HISTORY & DEVELOPMENT

It is designed by Gabriele Diamanti.

Eliodomestico costs approximately 50$, but it is an open-source design and anyone can use the schematics to build it locally.

5.5.2 DETAILS

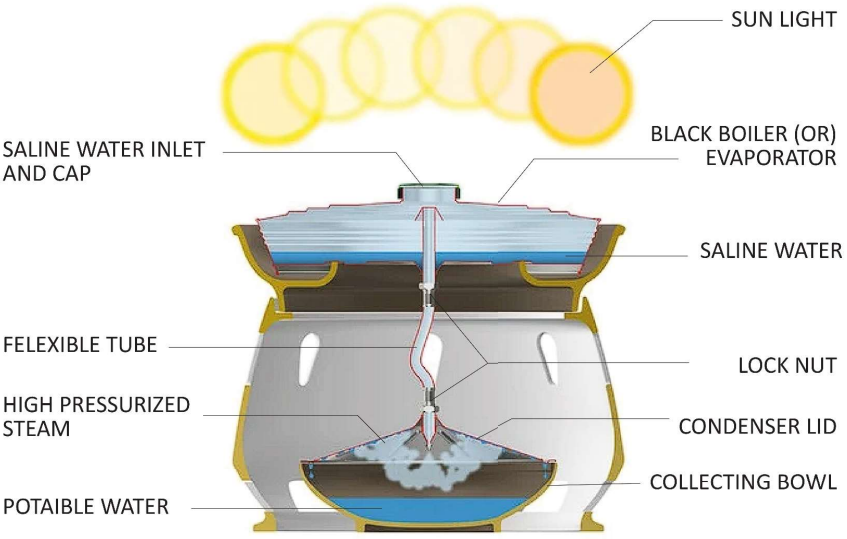


Figure 49: Black metal boiler

Figure 50: Earthenware structure

Figure 51: Holes for the circulation of the air in the condenser area

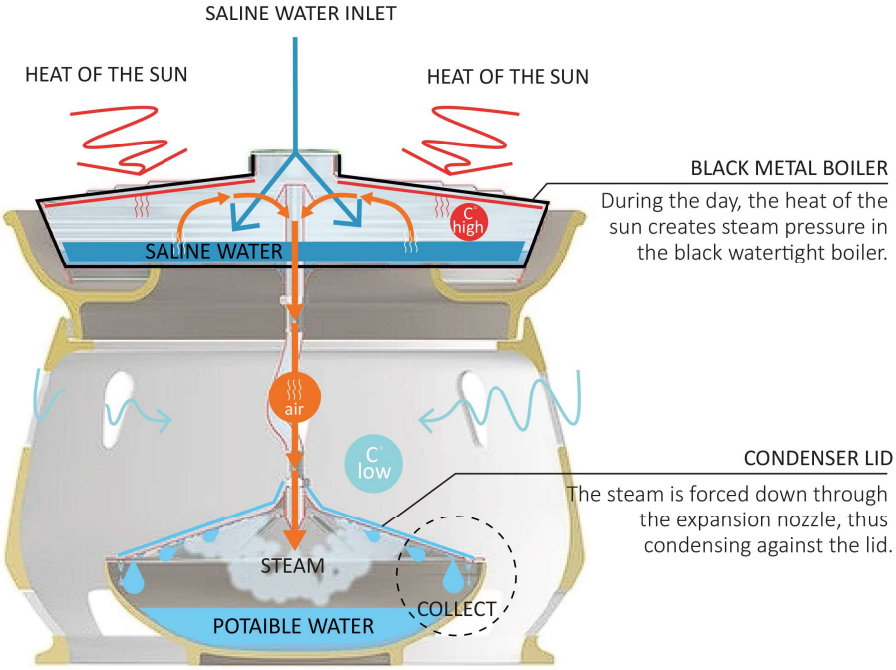
Figure 52: bottom holes

5.5.3 FUNCTION

It works like an upside down coffee maker: during the day, the heat of the sun creates steam pressure in the black watertight boiler. The steam is forced down through the expansion nozzle, thus condensing against the lid.



X The shape of the collecting bowl isn't appropiate for transporting the water and pour the water to another bowl or bottl or exe



X Water Distilled process removes almost all impurities from water, including removing healthy minerals like potassium, calcium and magnesium.

✓ There is no glass to keep clean (in a basin still if the glass is dirty, there are efficiency losses)

✓ The salt stays only in the evaporator. In the pipe it runs just pure steam and drops of water (pure H2O)

✓ Nothing in the system can be clogged up, because when the water evaporates, the salt cannot go up with the moisture, but it stays on the bottom.

5.5.4 AVAILABILITY

Publicly available: no

Countries where available: Currently in prototype stage

Price range (USD): 20 to 50 USD

5.5.5 ANALAYSIS

Sustainable development	✓
Simple construction	✓
No electricity	✓
Local materials	✓
Easy maintenance	✓
Deployable	✓
Low-cost	✓

Social manufacturing	X Fabricated
Community gathering	X

It is a perfect solution for the regions that people don't have access to potable water. ✓

The only maintenance to do (like once in a month) is to unscrew the pipe, bring the evaporator away and wash it with any kind of water. The purpose of this operation is just to bring away the salty sediment from the bottom of the evaporator... because after a very long time the sediment can fill up the evaporator. ✓

5.6 PORTABLE SOLAR DISTILLER

A concept of this project is based on the three key principles Anticipate, Innovate and Engage, has the ability to purify up to 18 litres of undrinkable or polluted water in a 12 hour period and allows to transform water that is not suitable for drinking or for the preparation of food in drinking water without energy consumption.

5.6.1 HISTORY AND DETAILS

The design was selected out of 2,000 entries from 66 countries to win Lexus Design Award 2021, which called on entrants to “design for a better tomorrow”.

Glogau was inspired by a term abroad in Chile while he was a student at the Royal Danish Academy in Copenhagen, Denmark. Working with social inclusion NGO Techo, Glogau travelled to the community of Mejillones which faces “extreme climates”, the designer says.“I spent time inside the informal settlement communities,” he adds. *“I learnt about some of the significant daily challenges they face, in particular access to freshwater and electricity.”*He says he was particularly interested in finding ways to “produce resources through passive and low-tech designs”.

The designer also investigated biomimetic design with the use of local flora and fauna.

5.6.2 STRUCTURE AND DETAILS

Glogau developed a prefabricated version of the design, which comes with a flat-packed canopy and funnel as well as a simple manual for how to assemble an hourglass-shaped support structure for the canopy from bamboo sticks and rubber bands.

The prefabricated model consists of a plastic canopy to hold the water, an internal funnel to collect the liquid and a bamboo support structure.But he also developed instructions for how to construct the distiller with the help of more accessible, local materials using a plastic bottle for a funnel and two reclaimed plastic sheets stitched together for the tarp.

This can be adjusted to use only canopy and funnel, according to Glogau, meaning that the structure could be suspended between buildings for example. *"This hybrid version also acts as a shelter for shade with space underneath to stand or sit,"* he says.

The design is also adaptable in terms of materials used. A locally sourced version might use wooden parts, explains Glogau, or a plastic bottle as the funnel.

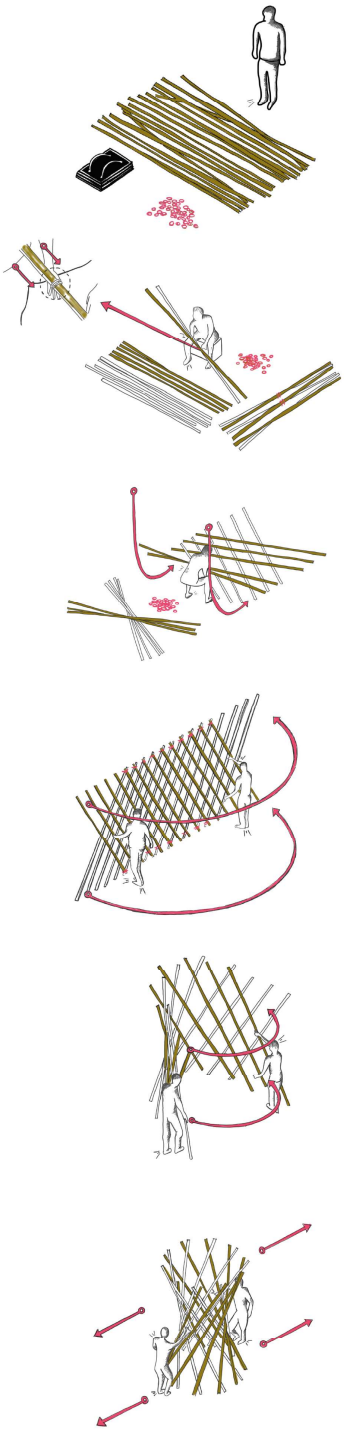
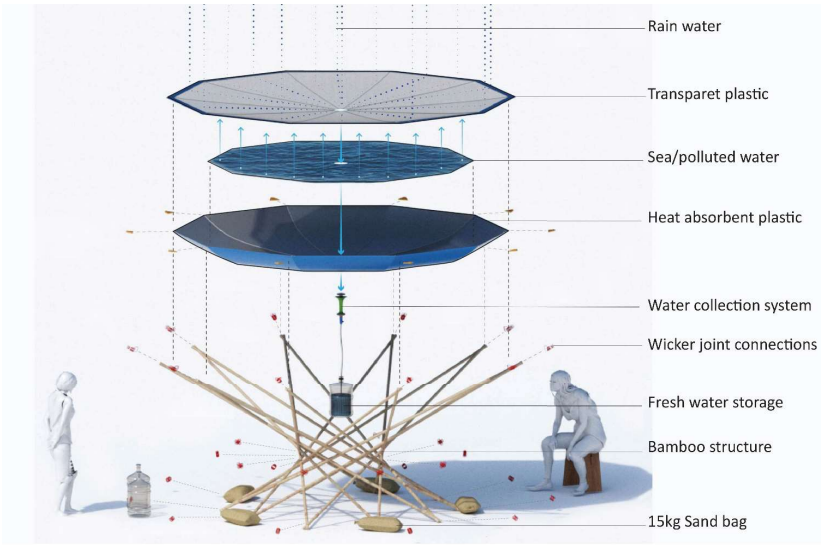


Figure 53: Construction processes

5.6.3 FUNCTION



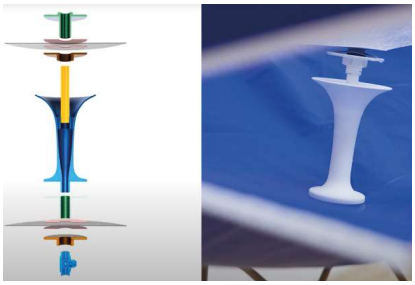


Figure 54: Water collection system(funnel)

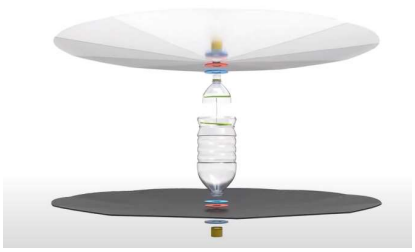


Figure 55: The alternative plastic bottle as the funnel

The distillation works through solar desalination, which relies on two processes: evaporation and condensation. This mirrors the hydrological cycle where water is evaporated by the sun, condensed into clouds and precipitated through rain.

In Glogau's design, the 2.2m diameter canopy is made from two durable plastics which have been sewn together. The upper layer is a transparent UV resistant material which allows solar energy to reach the water while the bottom layer is a heat absorbent plastic which contains the water.

After water is collected, energy from the sunlight separates the contaminants and freshwater through evaporation. This leaves behind impurities such as salt brine, heavy metals and pathogens, the 'Microgrooves' which are inspired by the structure of leaves channel these droplets towards the centre where they collect in the funnel. This funnel can be accessed by a tap or directly connected to an empty bottle.designer explains. The vaporised freshwater is then condensed as droplets on the inner surface.

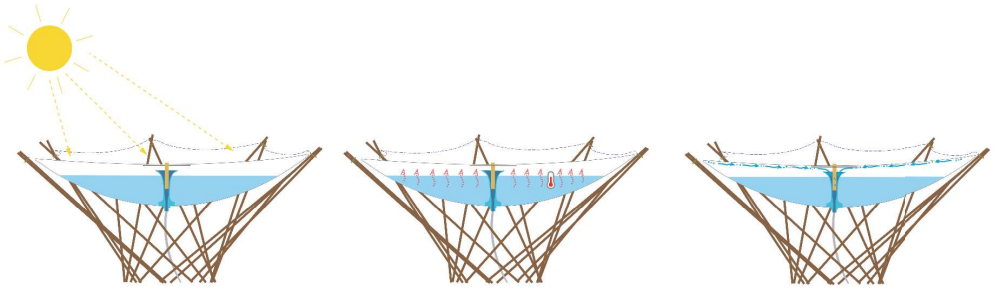
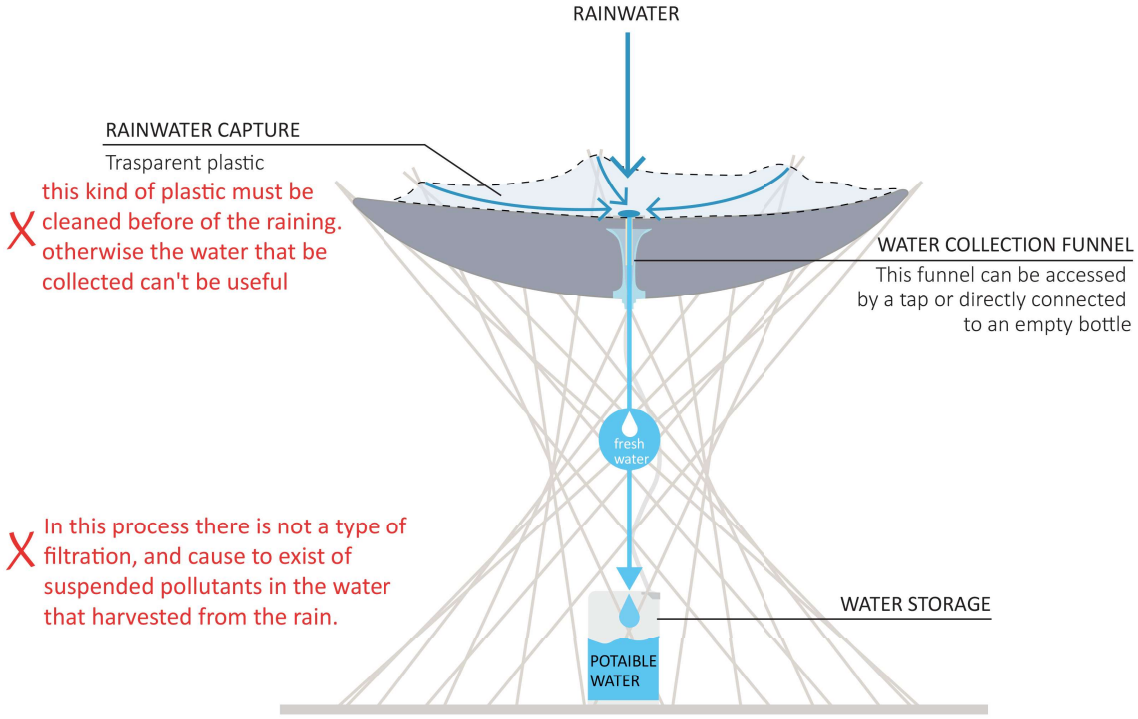


Figure 56: Function of Portable solar distiller

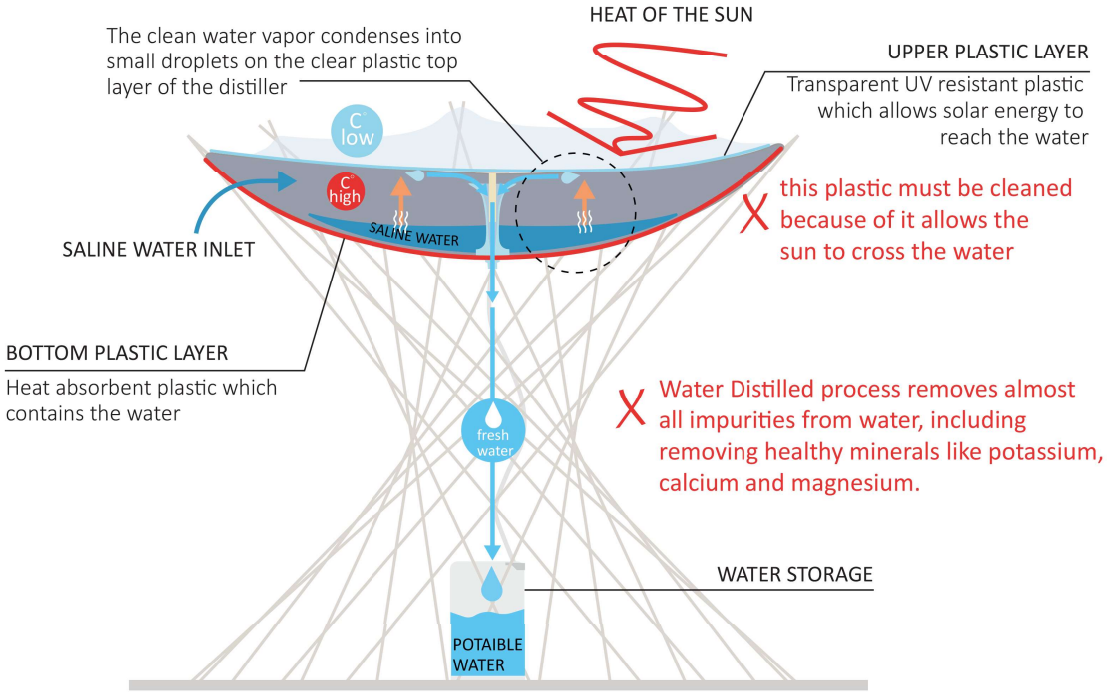
Figure 57: Different dimensions of structures

This product has two kind of functions:

- **RAIN HARVESTING**



- **CONDENSER**



5.6.4 ADVANTAGES

"The distiller can either be prefabricated, completely locally sourced and manufactured or a hybrid of both – making the design adaptable to local surroundings and available resources."

This sets the design apart from many conventional solar stills, which rely on heavy, inclined glass covers and metal basins that are not as easily accessible for marginalised communities. Beyond providing an essential resource, the distiller's suspended design also offers a place for the community to gather and shelter from the sun. Glogau's hope is that the distiller's easily deployable design, which is designed to be easily transported and assembled, can contribute to providing clean drinking water to communities living in informal settlements, who will suffer most from the impacts of climate change.

The design is adaptable to local surroundings and available resources.

Figure 58: The structure could be suspended between buildings

Compration of Portable Solar Distiller with many conventional Solar Stills:

5.6.5 ANALYSIS

Sustainable development	✓
Simple construction	✓
No electricity	✓
Local materials	✓
Easy maintenance	✓
Deployable	✓
Low-cost	✓

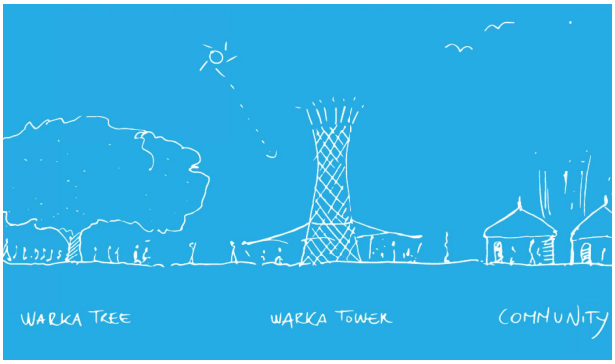
Social manufacturing	✓
Community gathering	✓
Economic grows	✓

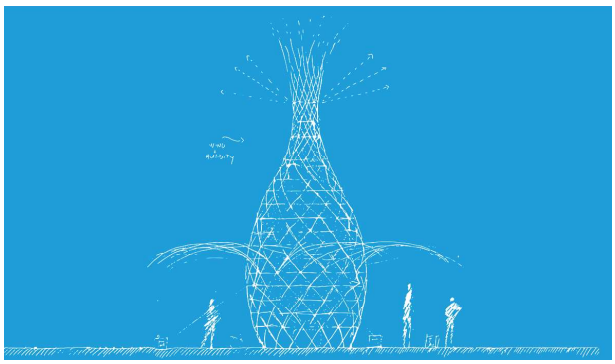
5.7 WARKA WATER

The Warka Tower is designed to harvest water from the atmosphere (rain, fog, dew) providing an alternative water source for rural populations that face challenges accessing drinkable water. It is a passive structure, it functions only by natural phenomena such as gravity, condensation & evaporation. Easy to maintain it is operated autonomously by the villagers. The design depends on the local meteorological conditions, the geomorphological characteristic of the site, and the local culture.

The tower that captures drinking water from the air (Warka towers) do not require electrical power and owned and operated by the villagers and also serve as community places.While the main aim of the Warka Water project is to alleviate the scarcity of potable water for people, it is also envisaged to provide water for livestock, smal-scale irrigation and vegetable gardens. This can help alleviate poverty and create self-sufficiency in this village.Manufacturing the Warka Water tower locally and sourcing indigenous materials creates jobs and a further boost to the local economy.

Air always contains a certain amount of water vapor, irrespective of local ambient temperatures and humidity conditions. This makes it possible to produce water from air almost anywhere in the world. Locations with high rates of fog or humidity are the best places to install the Warka Tower. The water harvesting capacity strictly depends on the meteorological conditions and the aim is to distribute from 100 liters (10 to 20 gallons) of drinking water every day for use of the community.





5.7.1 HISTORY & DEVELOPMENT

Traveling from Italy to Ethiopia was like visiting a whole new world for Italian architect, Arturo Vittori. During his first trip there in 2012, he spotted a woman struggling to carry a large container of water. His instinct was to help her, but the size and weight of the container was almost unmanageable. He was shocked by her ability to carry the container for several miles, all the way back to her village.

Over the next few days, Vittori despite the fact that many natural sources of water are often contaminated with parasites and human and animal waste. Because water is so scare, women and children often have no choice but to travel long distances to collect water for their families. Some of the natives are even unaware that the bacteria in the water can make them sick, causing water borne illnesses to run rampant among Ethiopian communities, which in some cases can cause death, especially in young children.

To help improve this dramatic situation, we made it our mission to find a solution and help these people with Warka Water : An environmentally, socially and financially sustainable solution to potable water.

The design for the Warka Tower comes from inspiration of the “Warka” tree. This is a tree native to Ethiopia and is an important community meeting point.

Figure 59: Warka tree (Ficus vasta)- Ethiopia

The design and construction of the Warka Water tower was adapted from local knowledge, vernacular architecture and the beautiful craftsmanship of Dorze huts, which are constructed from split bamboo interwoven into upright stands.

The elegant triangulated frame design was initially inspired by the masero

Figure 60: Masero(a type of clay pot used by local women to carry water from streams and wells in rural Ethiopia).- Ethiopia

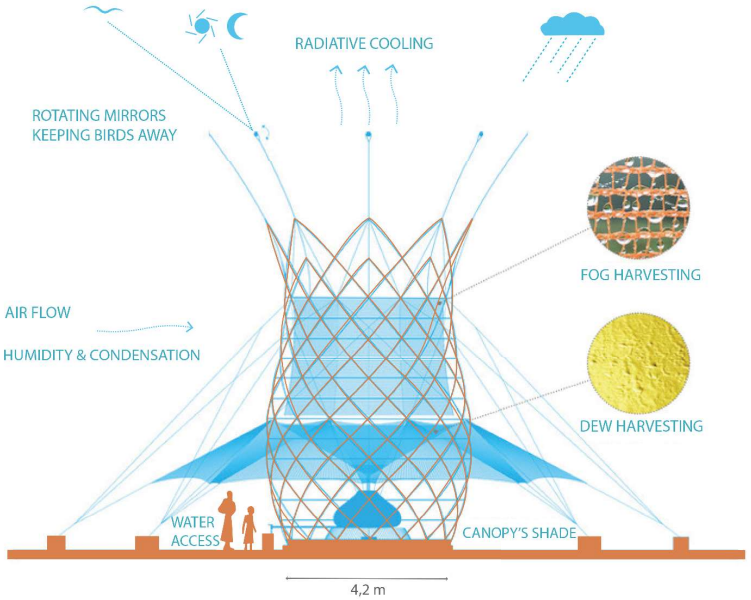


Figure 61: Warka Tower is designed to harvest potable water from the atmosphere (it collects rain, harvests fog and dew).

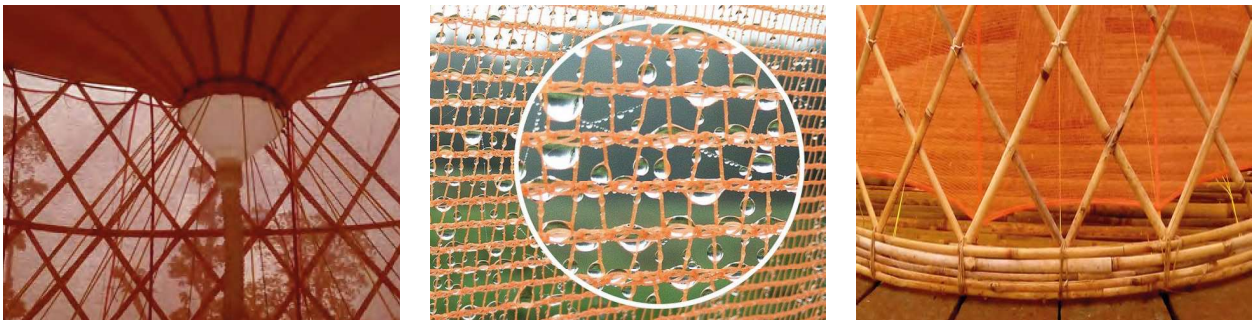
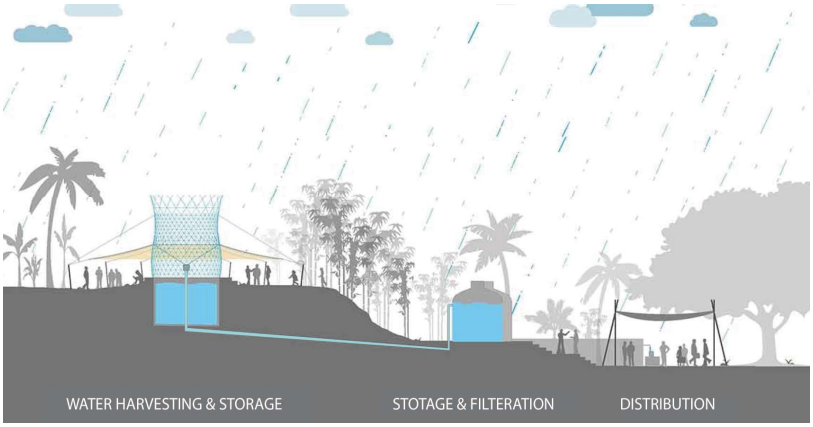


Figure 62: Water is collected from rain,fog and dew. the polyester net membrane captures water, filters and channels it into a 3000 litres water collectionPVC tanker.

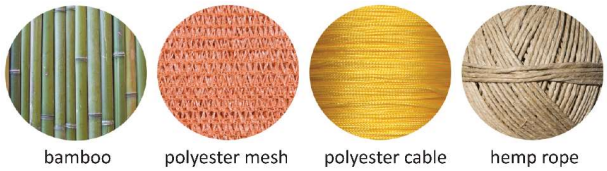


5.7.2 STRUCTURE & DETAILS

The structure itself was constructed from split local bamboo canes woven into a lattice pattern, optimised for lightness and strength while offering stability and robustness. It is modular and quick to assemble, making it easy to transport and manoeuvre. There are five modules layered from top to bottom, securely connected to each other using natural fibre ropes. The structure sits on a circular foundation of easily assembled local stone blocks and is further strengthened by using a circular form with eight fixing points placed radially around it. These points are securely anchored to the frame, while different size triangulated ropes are fixed around the structure, stabilising the tower and helping against strong winds.Water collected from rain, fog and dew rolls down over this net into a polyester sandwich membrane used as a funnel and filtration channel and on into a 3,000 litre water collection PVC tank.

Some of the materials are:

Bamboo, Earth, Wood,Raffia Palm Leaves, Raffia Bamboo canes, Lianas, Dry Straw, Dry Reeds.



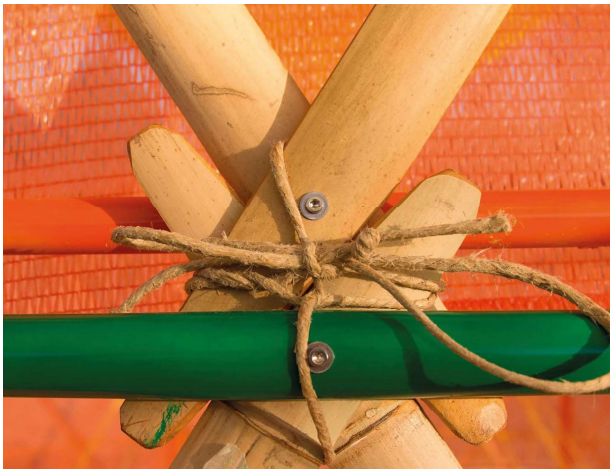


Figure 63: Details of the junction points

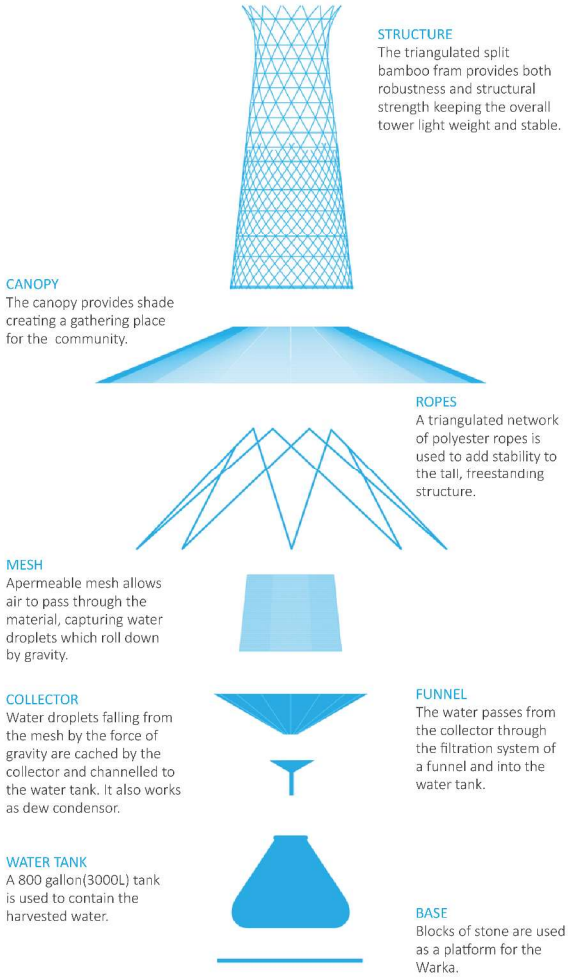


Figure 64: Five modules are layered from top to bottom and connected to each other using natural fibre ropes

Figure 65: Work in Progress - WW 3.2 - First Test Assembly with hemp ropes

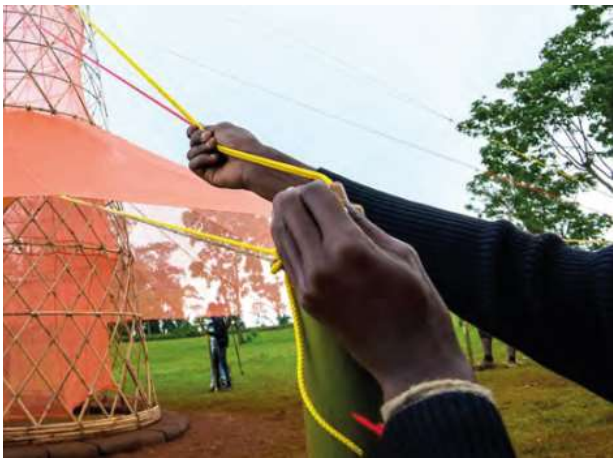


Figure 66: Several ropes stabilised the tower against strong winds

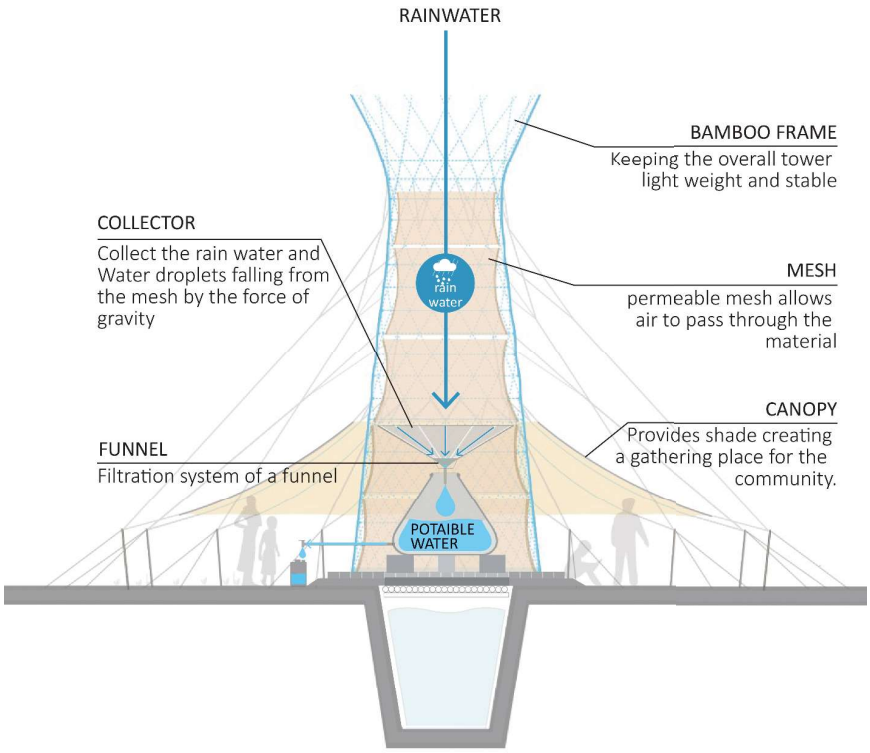
Figure 67: Circular fondation made of stone blocks

5.7.3 KEY DETAILS OF WARKA WATER 3.2.

-Daily water collection: 50 to 100 L, annual average
-Water tank storage: 1000 L
-Construction: 4 days, 6 people (by hand, no electrical power machinery required)
-Assembly: 3 hours, 4 people
-Weight: 60 kg
-Materials: Bamboo, hemp, metal pins, bio-plastic
-Dimensions: 10 m – Footprint 4,2 m
-Surface Area: Mesh 80 sq. m, Collector 43 sq. m
Canopy 87 sq. m
-Cost: ~ $1,000 (production in Ethiopia)
-Maintenance: easy to be maintained, cleaned and repaired.

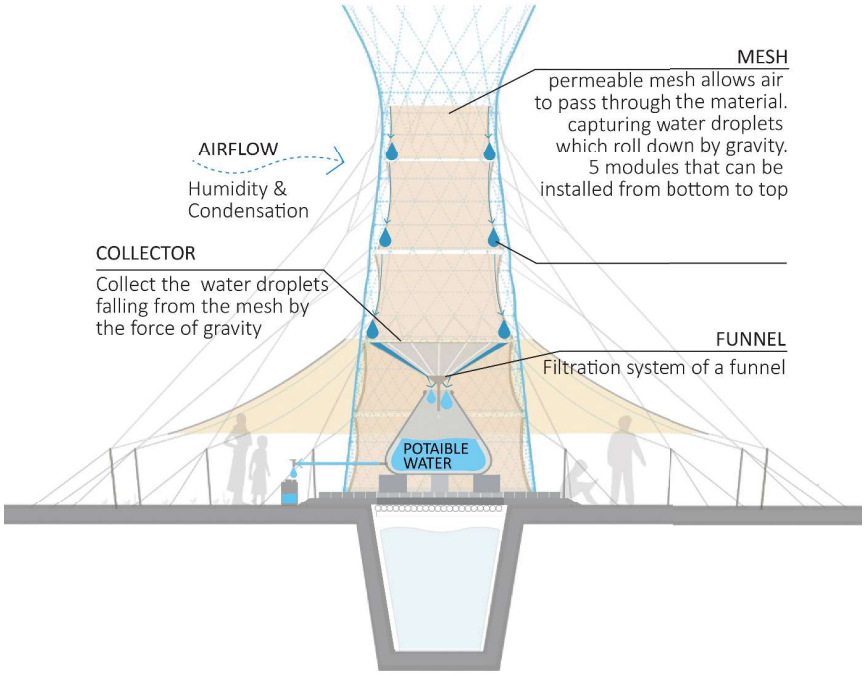
5.7.4 FUNCTION

- **RAIN HARVESTING**



- **FOG & DEW HARVESTING**

Locations with high rates of fog or humidity are the best places to install the Warka Tower.



5.7.5 AVAIBALITY & COST

The construction of the Warka Water tower takes about four weeks for fabrication plus one day of assembly time by a team of ten people. It is configured and designed so that the local communities could build it repeatedly without extra scaffolding or special tools.

The prototype built in Dorze cost 1,500 USD for materials, although some parts like the bamboo were donations from local industries and not accounted for in the cost.

Since 2012, have been developed several design concepts and constructed 12 full-scale prototypes in order to test different materials within varying environmental conditions.

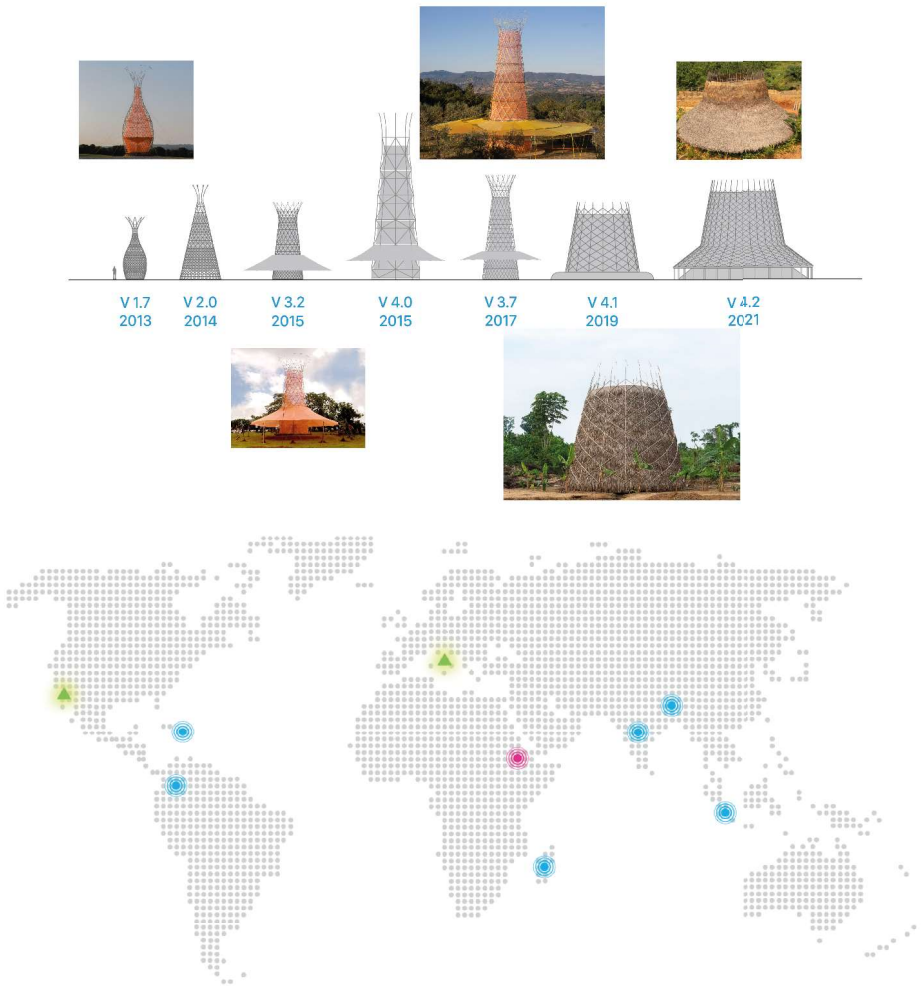


Figure 68: It is currently in use in “Haiti, Madagascar, Colombia, Brasil, India, Sumba, and Cameroon, among others” Warka_Water_Inc.

5.7.6 *ADVANTAGES*

-The aim of the Warka Water project is, in the long run, to create economic and social opportunities based on the manufacturing, setting up and management of the towers.

-Maintenance requires only that the mesh and container are cleaned regularly and broken parts are fixed.

- It is a flexible, portable and temporary structure designed to leave no trace on the environment after removal.

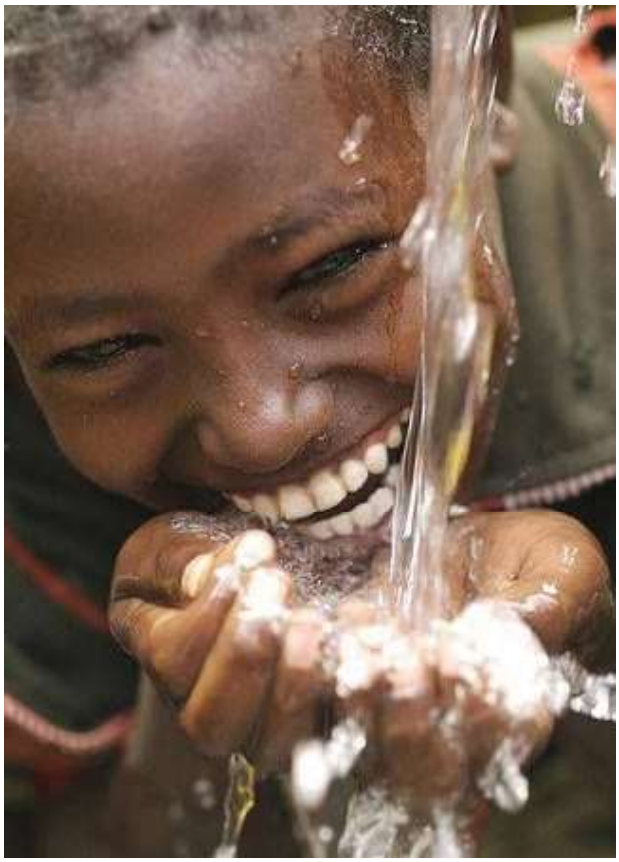
5.7.7 ANALYSIS

Sustainable development	✓
Simple construction	✓
No electricity	✓
Local materials	✓
Easy maintenance	✓
Deployable	X
Low-cost	✓

Social manufacturing	✓
Community gathering	✓
Economic grows	✓

6 PROJECT CONTEXT

6. PROJECT CONTEXT



"Access to safe water must be a national concern because the outcomes of unsafe water and poor sanitation and hygiene that manifest in child illnesses and deaths have many other serious consequences connected to nutrition, health, education, poverty and economic growth and development," Kamenga emphasized.

One in five children globally do not have enough water to meet their everyday needs, says UNICEF's Executive Director, Henrietta Fore, and adds that a projection made by a 2017 UNICEF report indicates that almost 1 in 4 children globally will live in areas of extremely high water stress by 2040. Children and families in vulnerable communities will be hit the hardest in this world water crisis.

There are over 163 million people living in India without household access to safe water, a figure higher than many countries have people. Poor management of water resources in India is one of the major problems preventing adequate water access. Aquifers are the main source of water in the country and the use of hand pumps is quickly depleting shallow aquifers. Other countries in Asia, such as Indonesia and Pakistan, have some 32 million and 16 million people, respectively, who also have to go without safe water in their own homes.Globally, about 63 percent of the population in Papua New Guinea lives without safe water access in their homes. In the capital city, Port Moresby, many people live in areas that are outside of existing water utilities and infrastructure.

More extreme weather and rising sea levels will likely lead to more uncertainty and unreliable water supplies.

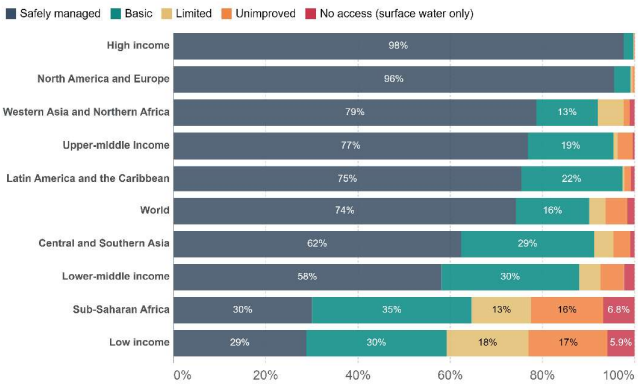


Table 11:Share of the population with access to drinking water facilities,2020
WHO/UNICEF Join Monitoring Programme(JMP) for Water Supply and Sanitation

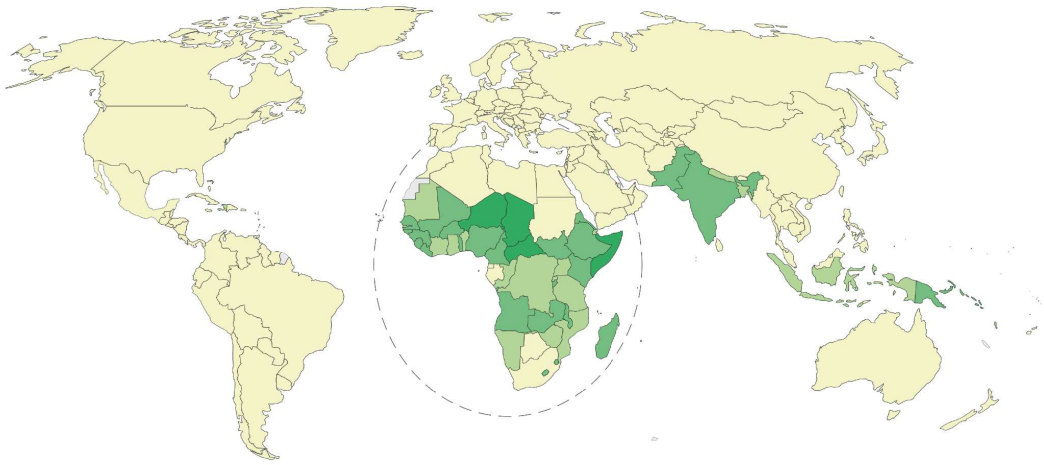


Figure 69: Death rates from unsafe water sources,2019
Death rates are measured as the number of deaths per 100,000 individuals
IHME, Global Burden of Disease(2019)

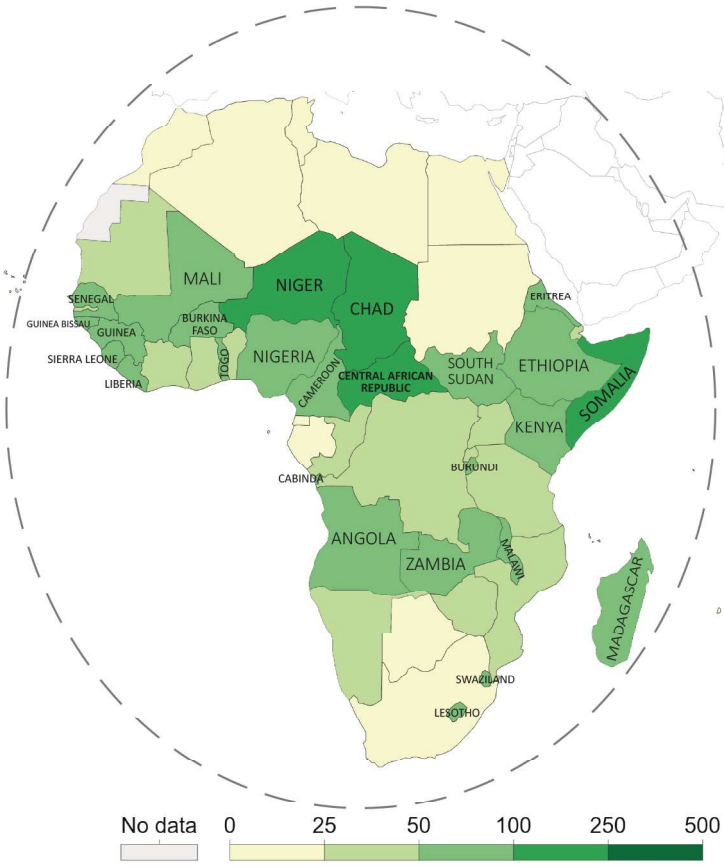


Figure 70: Africa's Death rates from unsafe water sources,2019
Death rates are measured as the number of deaths per 100,000 individuals

There are limited sources of water available to provide clean drinking water to the entire population of Africa. Surface water sources are often highly polluted, and infrastructure to pipe water from fresh, clean sources to arid areas is too costly of an endeavor. Groundwater has the benefit of being naturally protected from bacterial contamination and is a reliable source during droughts. However, the high costs associated with drilling for water, and the technical challenges in finding sources that are large enough to serve the population in need, present challenges that limit tapping the resource.

The implications of lack of clean water and access to adequate sanitation are widespread. Young children die from dehydration and malnutrition, results of suffering from diarrheal illnesses that could be prevented by clean water and good hygiene .

Diseases such as cholera are spread rampantly during the wet season. Women and young girls, who are the major role-players in accessing and carrying water, are prevented from doing incomegenerating work or attending school, as the majority of their day is often spent walking miles for their daily water needs. They are also at an increased risk for violence since they travel such great distances from their villages on a daily basis, and are even at risk when they must go to the edge of the village to find a private place to relieve themselves.[150]

Figure 71: Surface water sources are often polluted

Figure 72: Groundwater
https://www.worldvision.org/

Figure 73: Women and young girls, who carrying water
https://blogs.unicef.org/

150 https://rafiufishbone.blogspot.com/

African Countries	Mean annual precipitation mm	Mean annual temperature °C	Population	population with no access to safe drinking water	P.P with no access to safe drinking water
SIERRA LEONE	2653.41	26.54	7,976,983	2,682,296	33%
LIBERIA	2451.04	25.45	5,057,681	1,091,224	21%
GUINEA	1789.18	25.85	13,132,795	2,652,244	20%
GUINEA BISSAU	1612.26	28.05	1,968,001	359,601	18%
CAMEROON	1627.26	24.81	26,545,863	5,684,802	21%
MADAGASCAR	1470.22	22.64	27,691,018	11,753,533	42%
CENTRAL AFRICAN REPUBLIC	1371.77	25.47	4,829,767	1,415,349	29%
TOGO	1215.95	27.34	8,278,724	2,702,245	32%
NIGERIA	1186.76	27.30	206,139,589	57,058,296	27%
MALAWI	1042.20	22.65	19,129,952	1,641,040	8%
ANGOLA	1041.70	21.77	32,866,272	14,221,034	43%
SOUTH SUDAN	995.75	27.97	11,193,725	4,425,567	39%
ZAMBIA	982.32	22.23	18,383,955	5,494,259	29%
BURUNDI	957.87	22.92	11,890,784	2,448,567	20%
ETHIPOPIA	850.14	23.37	114,963,588	43,056,741	37%
BURKINA FASO	831.09	29.26	20,903,273	3,205,580	15%
LESOTHO	787.37	12.36	2,142,249	374,742	17%
KENYA	726.05	25.08	53,771,296	17,619,228	32%
SENEGAL	724.03	28.91	16,743,927	3,134,369	18%
CHAD	352.32	27.65	16,425,864	6,942,600	42%
MALI	329.44	29.21	20,250,833	3,134,369	15%
SOMALIA	277.79	26.95	15,893,222	6,400,000	40%
ERITREA	267.71	26.63	3,546,421	1,410,669	39%
NIGER	184.24	28.05	24,206,644	8,360,695	34%

181,020,717
People in African countries who have enough rain but don't have access to safe drinking water

Table 12:African Countries with the more Death rate from unsafe water
https://www.worldometers.info/water/access-to-safe-water/
https://www.worldometers.info/population/countries-in-africa-by-population/

At this stage, I have selected some of these countries (based on the percentage of deaths due to lack of unsafe water) and have investigated the weather and climate conditions, along with the living conditions of the villages in these regions in general.

6.1 NIGERIA

Mean annual temperature is 27.30 °C

Mean annual precipitation is 1186.76 mm

Nigeria is characterized by three distinct climate zones, a tropical monsoon climate in the south, a tropical savannah climate for most of the central regions, and a Sahelian hot and semi-arid climate in the north of the country. This leads to a gradient of declining precipitation amounts from south to north. The southern regions experience strong rainfall events during the rainy season from March to October with annual rainfall amounts, usually above 2,000 mm, and can reach 4,000 mm and more in the Niger Delta.

The central regions are governed by a well-defined single rainy season (April to September) and dry season (December to March).Annual rainfall can reach up to about 1200 mm. In the north, rain only falls from June to September in the range of 500 mm to 750 mm. The rest of the year is hot and dry.

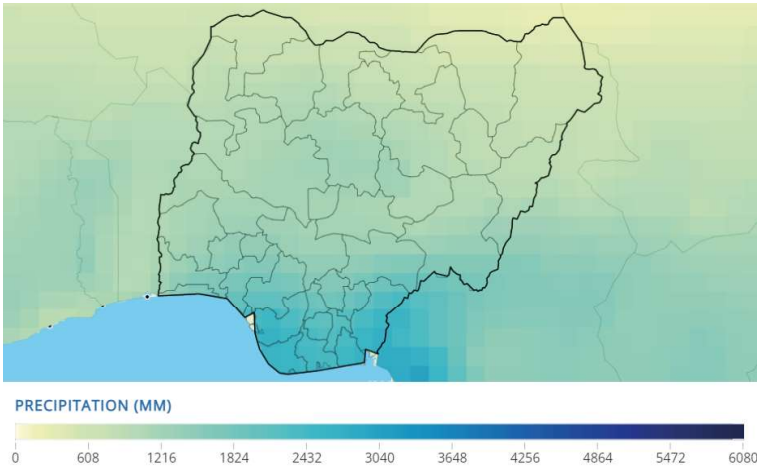


Figure 74: Observed climatology of precipitation 1991-2020 , Nigeria
https://climateknowledgeportal.worldbank.org/

Average monthly temperatures ranging between 24°C (December, January) and 30°C (April). Mean annual precipitation is 1,165.0 mm. Rainfall is experienced throughout the year in Nigeria, with most significant rainfall occurring from April to October and with minimal rainfall occurring November to March.

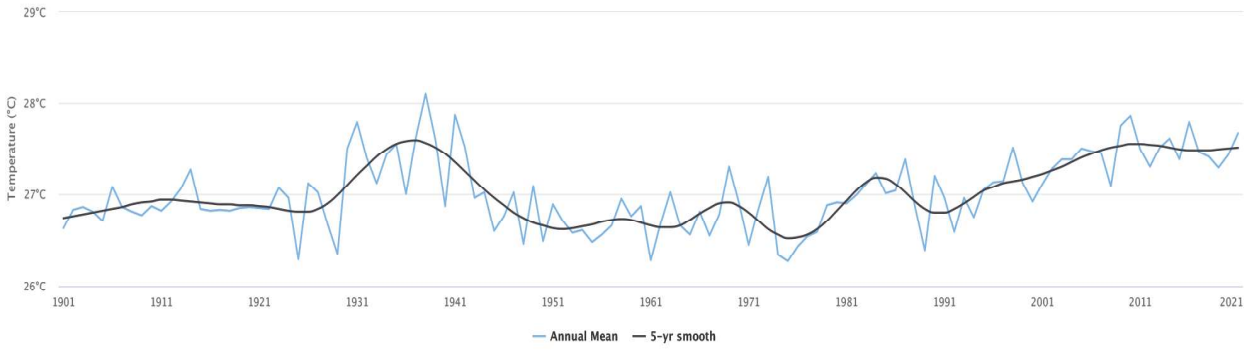


Figure 75: Observed Average Annual Mean-Temperature of Nigeria for 1901-2021

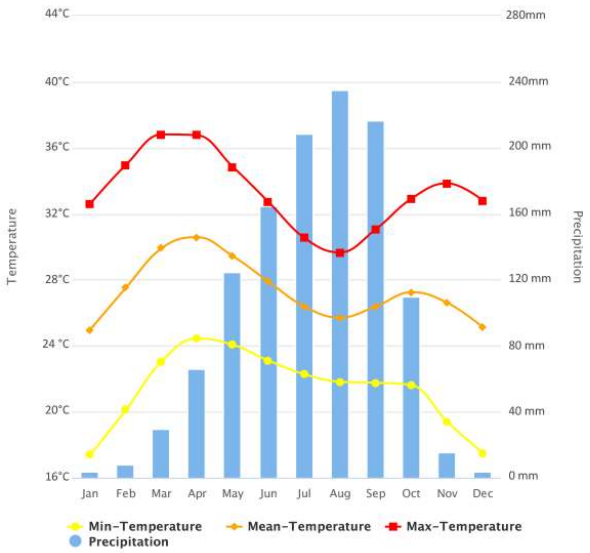


Figure 76: Monthy climatology of Min-Temperature, Max- Temperature, Mean Temperature & Precipitation 1991-2020 in Nigeria
www.Highcharts.com

Most structures in the various kingdoms were built using earth, grass and stone, common materials used in African architecture. While African architects chose the materials because they were readily available, the structures were designed to primarily repel invaders from other tribes.

Figure 77: Oloko Village,Cross River State Nigeria

6.2 ETHIOPIA

Mean annual temperature is 23.37 °C

Mean annual precipitation is 850.14 mm

Ethiopia is a large land area with diverse topography results in different climates across the country as well as temperature and precipitation disparity across its regions.

The highland regions in the center and north of the country experience cooler climates. Seasonal rainfall in Ethiopia is driven mainly by the migration of the Inter-Tropical Convergence Zone (ITCZ) and there is strong inter-annual variability of rainfall across the country.

Ethiopia has three rainfall seasons: Bega, Belg, and Kiremt.

- **Kiremt** is the first rainy season, occurs from mid-June to mid-September and accounts for 50–80% of annual rainfall. Parts of central and northern Ethiopia experience a sporadic.
- **Belg** is the second wet-season, which often has less rainfall and occurs from February to May.
-Southern regions of Ethiopia experience two distinct wet seasons, Belg, from February to May, and **Bega** occurring from October to December, which has drier and colder conditions.

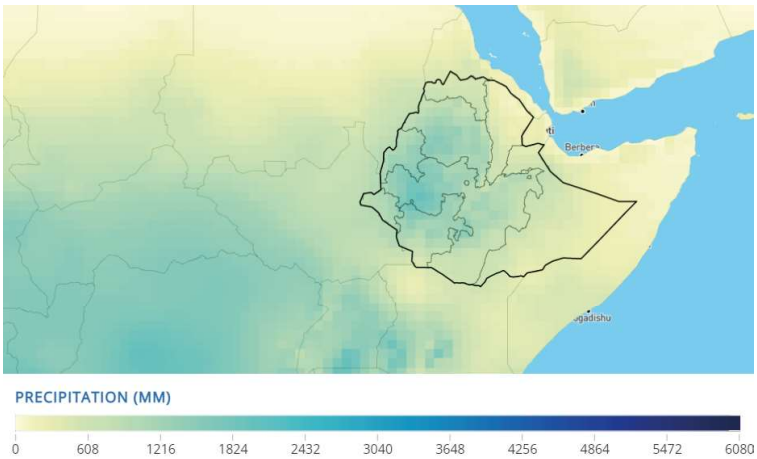


Figure 78: Observed climatology of precipitation 1991-2020
https://climateknowledgeportal.worldbank.org/

annual rainfall distribution is approximately 2,000 mm over the south-western highlands and less than 300 mm over the south-eastern and north-eastern lowlands. Temperatures across Ethiopia can range from –15°C over the highlands, to above 25°C in the lowlands.

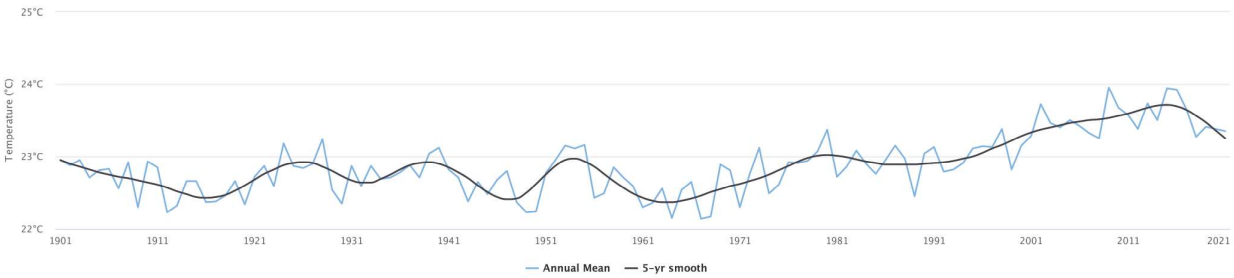


Figure 79: Observed Average Annual Mean-Temperature of Ethiopia for 1901-2021

- South and southwest are characterized by high rainfall and humidity

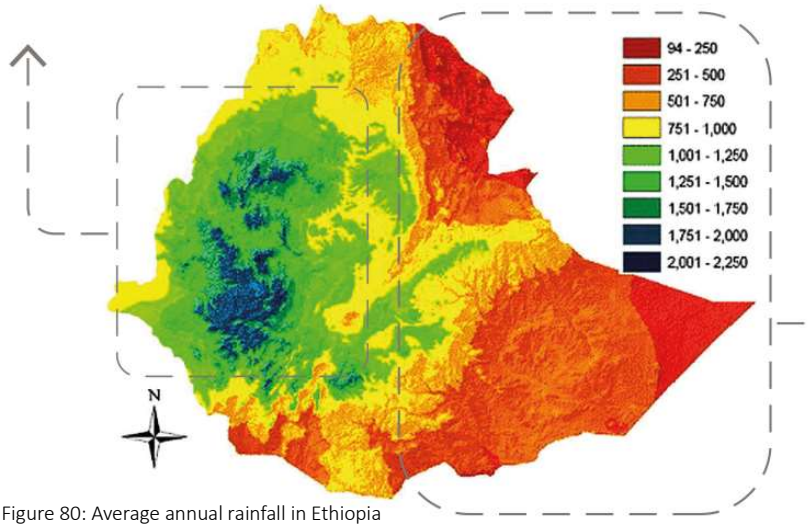


Figure 80: Average annual rainfall in Ethiopia
https://www.nationalparks-worldwide.com/eaf/ethiopia/ethiopia-weather.html

- The eastern corner of the country is very arid and experiences very little rainfall. the Afro-Alpine on the summits of the Semien and Bale mountains, and the northeast, east and southeast lowlands experiencing desert like conditions.

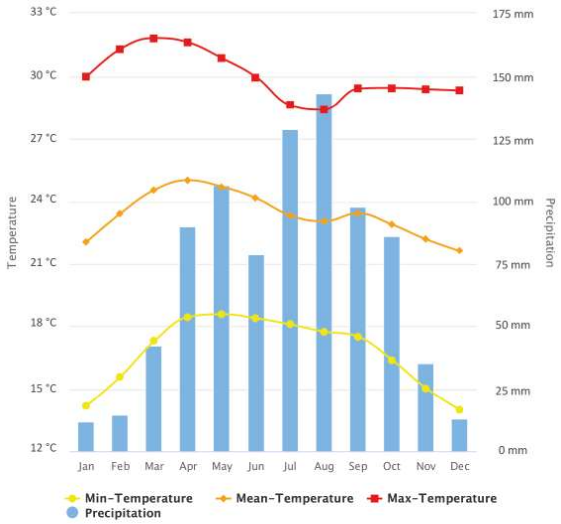


Figure 81: Monthy climatology of Min-Temperature, Max- Temperature, Mean Temperature & Precipitation 1991-2020 in Ethiopia
www.Highcharts.com

Some of the most traditional thatched houses are the **Dorze houses** at about 40 km from Arba Minch. These are completely woven houses from the leaves of false bananas over a structure of curved branches.

tukel, or traditional house which is made out of mud and grass, and is very basic. There is typically no electricity, no running water and no toilets. A village latrine is located right behind the Health Post. This is how most rural Ethiopians live except many are not as fortunate to have a Health Post that near. Many women walk hours on foot to receive care sometimes even sometimes when they are in labor.[151]

151 https://thirdeyemom.com/



Figure 82: Dorze houses in Chencha, southern Ethiopia
https://blackarchitecturalhistory.tumblr.com/post/80379446370/dorze-houses-in-chencha-southern-ethiopia-s

This is a traditional cut and braided bamboo circular house made by the Sidama people of Ethiopia. The dome, with its pointed top, is designed to repel heavy rain while in a circular dome that space would have a flat area, prone to leaks.

Bamboo played an important role in the rural economies of East Africa,



Figure 83: The architecture of the Konso villages is is different from traditional houses and dwellings elsewhere. The Konso people live in fortified villages enclosed by stone walls.
https://www.nationalparks-worldwide.com/

6.3 ANGOLA

Mean annual temperature is 21.77 °C

Mean annual precipitation is 1041.70 mm

Angola is a country located on the west coast of Southern Africa and it is the seventh-largest country in Africa. Like the rest of tropical Africa, Angola experiences distinct, alternating rainy and dry seasons[152].

Climate zone classifications are derived from the Köppen-Geiger climate classification system, which divides climates into five main climate groups divided based on seasonal precipitation and temperature patterns. The five main groups are A (tropical), B (dry), C (temperate), D (continental), and E (polar).[153] In the north, the rainy season may last for as long as seven months—usually from September to April, with perhaps a brief slackening in January or February In the south, the rainy season begins later, in November, and lasts until about February. In the north, the rainy season may last for as long as seven months—usually from September to April, with perhaps a brief slackening in January or February In the south, the rainy season begins later, in November, and lasts until about February. Climatic differentiation, and it decreases rapidly from north to south and in proximity to the coast. The Maiombe forest in the northern part of the Cabinda exclave receives the greatest amount of rainfall, about 70 inches (1,800 mm) per year, and Huambo, on the Bié Plateau, receives 57 inches (1,450 mm). In contrast, Luanda, on the dry coast, receives about 13 inches (330 mm), while the southernmost part of the coastal plain gets as little as 2 inches (50 mm).[154]

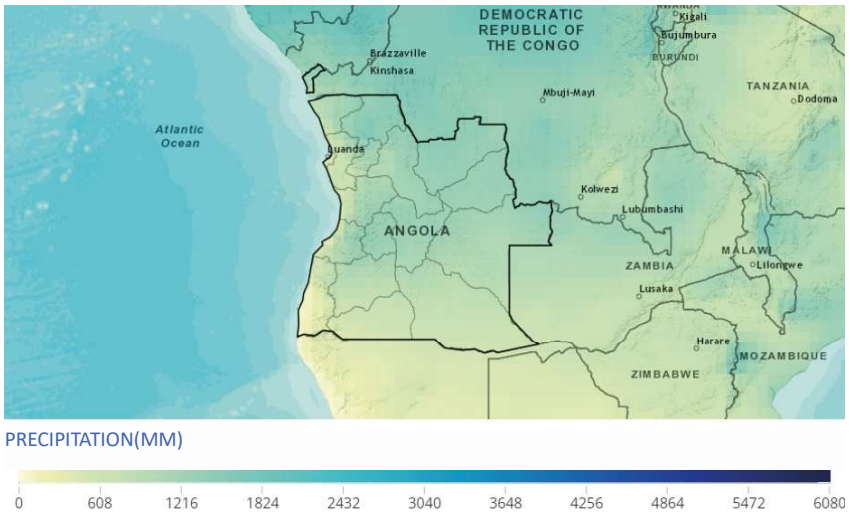


Figure 84: Observed Annual Precipitation 1991-2020 Angola
https://climateknowledgeportal.worldbank.org/

152 Collelo, Thomas, ed. (1989). Angola: a country study. Washington, D.C.: Federal Research Division, Library of Congress. pp. 57–61. OCLC 44357178. Archived from the original on 8 April 2022. Retrieved 19 June 2022.
153 https://climateknowledgeportal.worldbank.org/
154 https://www.britannica.com/place/Angola

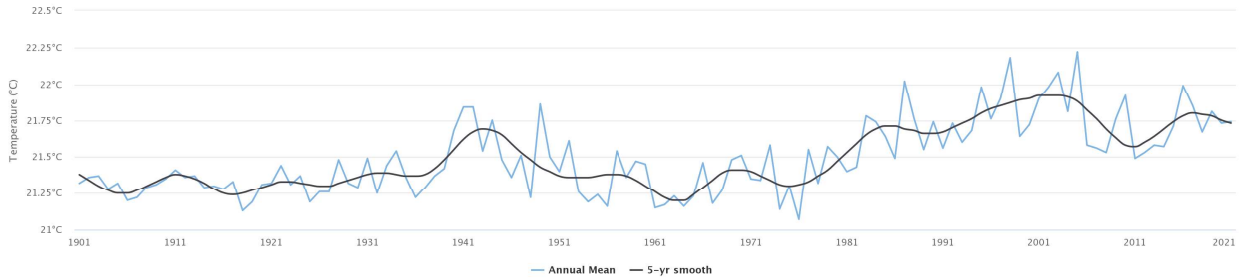


Figure 85: Observed Average Annual Mean-Temperature of Angola for 1901-2021
https://climateknowledgeportal.worldbank.org/

The rains coincide with the warmest months of the year with average temperatures ranging from 22-23°C. The dry season, known as "Cacimbo," occurs from June-September and is the coolest time of the year, with average temperatures between 18-20°C.

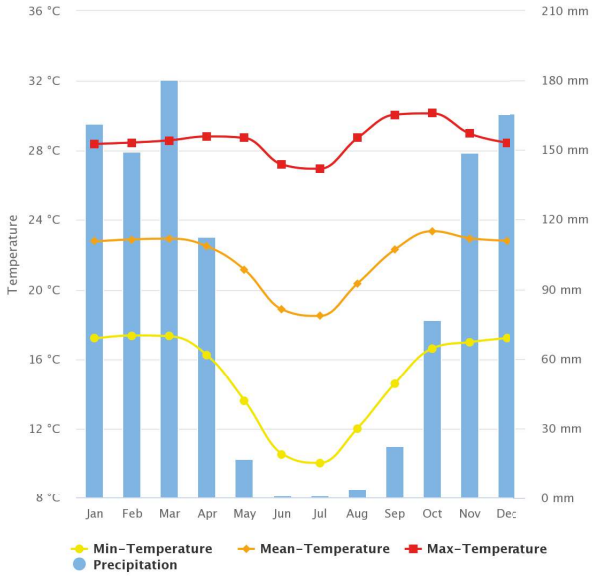


Figure 86: Monthy climatology of Min-Temperature, Max- Temperature, Mean Temperature & Precipitation 1991-2020 in Angola
www.Highcharts.com

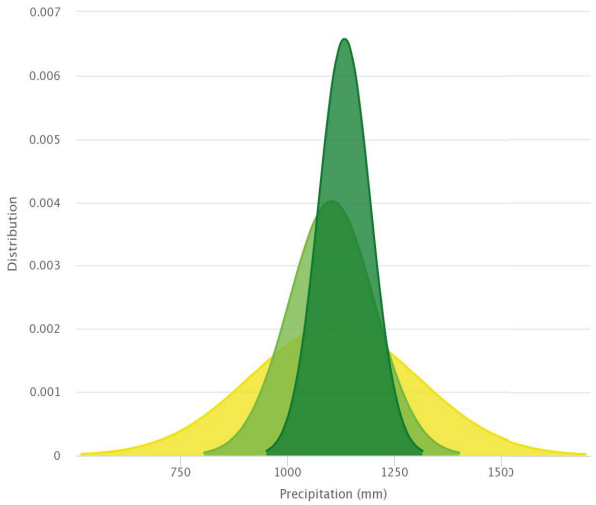


Figure 87: Change in distribution of precipitation; Angola
https://climateknowledgeportal.worldbank.org/

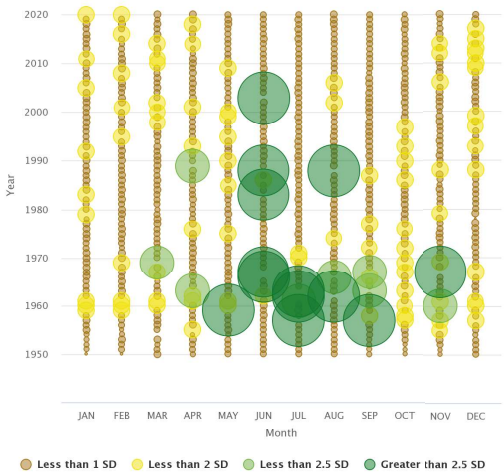


Figure 88: Change in event intensity of precipitation; Angola
https://climateknowledgeportal.worldbank.org/

Rural villages tend to be small in size. Housing is generally kept clean and is often constructed of adobe or brick and roofed with sheet metal. More-traditional construction techniques are still known to some, but for the most part, fewer homes are made with the traditional wattle and daub walls and thatched roofs. There is virtually no electricity in smaller rural villages, and most towns only have it intermittently. Running water is also intermittent or unavailable in many areas.[155]

Towards the north, however, rectangular or four-cornered houses with overhanging eaves or verandas as protection from the more abundant rainfall are increasingly used. While climate is an important influence on this change, European acculturation is also a factor.

The round plan, domed form cubata is still used as a menstrual hut and as a prayer house for certain of the animist groups. In some regions of the northeast only chiefs use a round house. This round and domed shelter, usually no more than 2.5 m (8 ft) in height, is the original, prehistoric house form.[156]

The traditional architecture in Angola comprises the most ancestral dwellings of the territory, called **"Cubatas"** or houses of straw. Currently it can be found in the rural area of the country. This architecture is self-constructed, spontaneous and without the intervention of scholarly specialists. However, it respects an internal rule based on the secular customs of the various ethnic groups, which retain their tradition.[157]


Figure 89: Cubatas


Figure 90: Roof beams


Figure 91: Village in Anogola

155 https://www.britannica.com/
156 A.Cain, Chokwe Traditional Architecture (Angola, NE) Encyclopedia of Vernacular Architecture of the World, Volume 3-VII-2-g p2002, Cambridge UP , October 2018
157 AF. Jivala Daniel Traditional Architecture in Angola Sustainability Strategies, May 2019

6.4 AFRICAN VILLAGES

In African Vernacular architecture is not grouped by national boundaries, but rather by climatic region.

Due to high levels of poverty, the vast majority of West Africans live in shelters made of the cheap, natural materials or vegetation found around them. As native vegetation is an expression of climate, grouping architecture by region links it directly to construction techniques. Building solutions and forms have thus evolved from the availability of materials and in response to climate. And while there may be an infinite number of architectural variations between villages, inhabitants are still limited to using what is available locally.

Life in equatorial Africa has always been very different. Communities are small and fragmented - there are over 10,000 tribes in what is now Nigeria alone.

An African village consists of a setilement of several families. The families are made up of twenty people or more so that one setilement has a population of about a hundred or more people. The farmsteads of the individual families seem like little villages themselves. Terrace houses are aligned along a circular exterior wall, while on the inside granaries, a cooking area and stables are situated. Every family owns a field, which often is cultivated in the traditional way with a pickaxe. Vegetables, grains and fruits are grown for their own needs. Whoever can afford it buys an ox to make field work easier. Life is very simple and is determined by rainy and dry seasons. Seeding begins at the end of the dry season; therefore, there's a lot to do at that time. The harvest takes place at the end of the rainy season, and everyone has to help, even the children. Afterwards, a thanksgiving is celebrated with home-brewed beer, millet- and grain dumplings and a holiday roast.

Figure 92: Bedik village Southeast Sénégal
https://it.m.wikipedia.org/wiki/File:Bedik_village_Southeast

Typical west African villages are the straw-covered round huts. They are built from clay, which is why it's nice and cool inside. The huts are not randomly arranged but according to a plan. In west Africa, the human body is the model for the village. The hut of the eldest is the head, the shoulders are the huts of person of high standing and the ribs, arms and legs are shaped from the dwelling places of the rest of the families.

The village square, the "stomach" of the body, lies in the middle. Children play in the shade of the trees. In the evening, the elders hold their conventions and discuss difficult decisions. This is where celebrations and religious rituals are also held. The **Apatam** is a place which is reserved for women only. It's a kind of pavilion made of logs and a straw roof.

In West Africa, the history of a village is ascribed to those ancestors, who founded it. In the past, only families with common ancestors were allowed to live in it. Today, people from different ancestries live in one village. However, the rules are still the same as those from a hundred years ago. The village elder is a kind of mayor. He controls the fate of the village. Hereby, he is advised by the family elders. He distributes the fields and the seeding material among the families and makes sure the coherence of the community is upheld. When a fight comes up between the families, he decides what to do.[158]

The African village, traditionally, is characterized by the "hut"; in other words, the hut is made up of wooden poles and clay soils are used to patch up the walling poles. In terms of the roof, again wooden poles are used and they are grass thatched. The buildings are conically shaped, and a collection of such huts in a defined space creates a "village".

Ron Eglash discovered that many African villages are actually built on fractal lines. They are built intentionally and reflect the nested hierarchies of the social structure. Depending on your position in the social structure will determine where your house is in the village fractal. He strangely found many different types of fractal villages, some based on circles, some on rectangles etc. but only found them in Africa and Southern India. He also found games and methods of divination which employed different computational fractal devises.

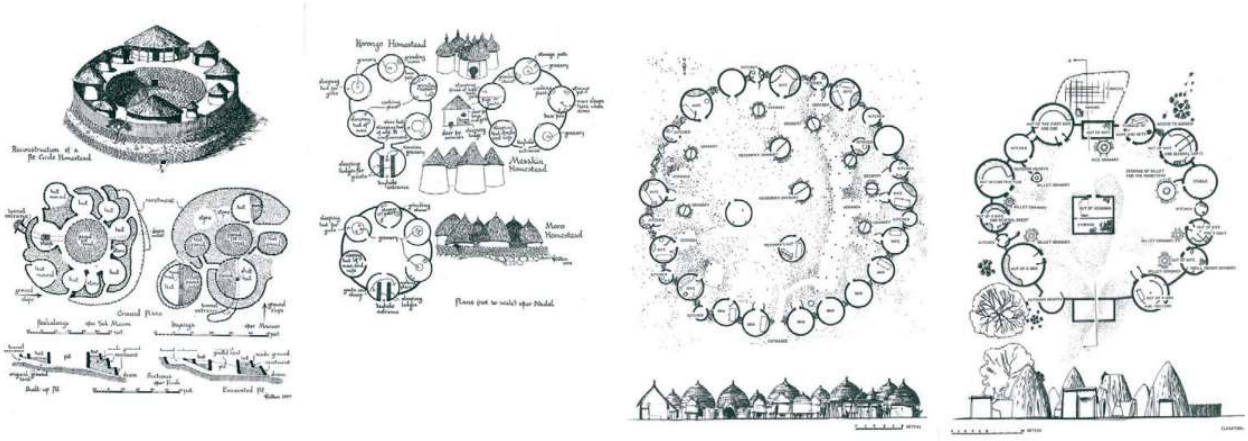


Figure 93: The building form takes its precedence from the settlement patterns of primitive African villages
https://www.proctorandmatthews.com/project/chester-zoo-entrance-and-education-centre

158 T.Teuscher1aJ.B.RosmancP.BaillodbA.Teuscherc, ABSENCE OF DIABETES IN A RURAL WEST AFRICAN POPULATION , Volume 329, Issue 8536, 4 April 1987, Pages 765-768

Figure 94: Kuron village, South Sudan
https://paxforpeace.nl/what-we-do/programmes/kuron-peace-village-in-south-sudan

Figure 95: village, South Sudan
https://vi.wikivoyage.org/wiki/Nam_Sudan

Figure 96: Waza national park, Cameroon
http://myafricansojourn.blogspot.com/2014/02/waza-national

Figure 97: Village, Cameroon
https://i.pinimg.com/originals/

Figure 98: Rural setilement, Ethiopia. Aerial view of a traditional vil-lagejust north of Addis Ababa, Ethiopia. This area is within the Oromo tribal district. The Oromo people, the largest ethnic group in Ethiopia, are mostly farmers and nomadic herders of livestock. Photographed in 2011.
https://www.sciencephoto.com/media/543769/view/rural-setilement-ethiopia

Figure 99: Village, Ethiopia
https://www.easyviaggio.com/ethiopia

Figure 100: Massai village, Kenya
https://www.joinupsafaris.com/treetop-maasai-village-tourp

Figure 101: Orma village, Kenya
https://commons.wikimedia.org/wiki/File:Orma_Village_Kenya.jpg

Figure 102: village, Kenya
https://chitans.inspiredimages.net/wp-content/uploads/slider10/kenya-village.jpg

Figure 103: village, Chad
https://www.worldwatchmonitor.org/countries/chad/

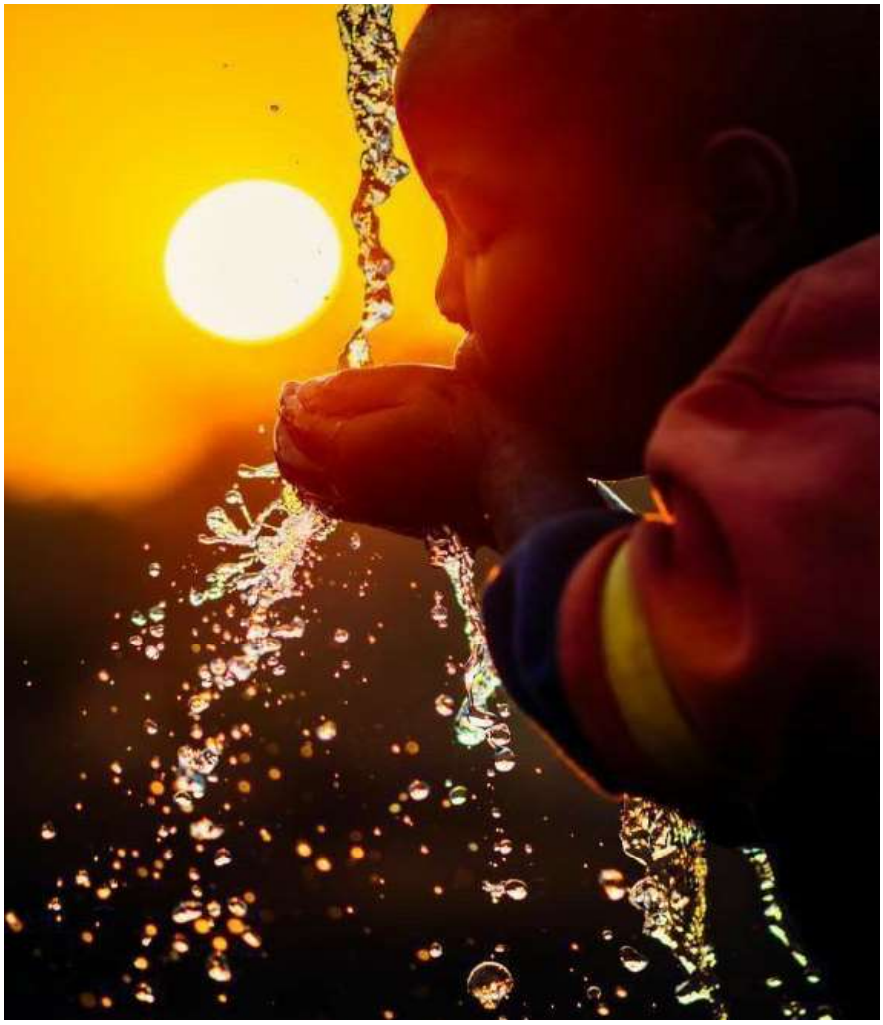
Figure 104: village, Chad
https://www.flickr.com/photos/varlamov/9624906978/in/photostream/

Figure 105: Village, Sierra leone, aeiral view
http://www.africavernaculararchitecture.com/sierra-leone

Figure 106: Village, Liberia, aeiral view
http://www.africavernaculararchitecture.com/gallery/liberia/

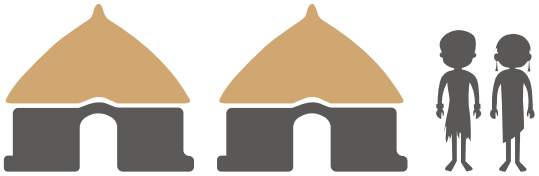
7

PROJECT



7. PROJECT

7.1 HOW THE PROJECT WAS FORMED



An African village consists of a settlement of several families. The families are made up of twenty people or more so that one settlement has a population of about a hundred or more people.

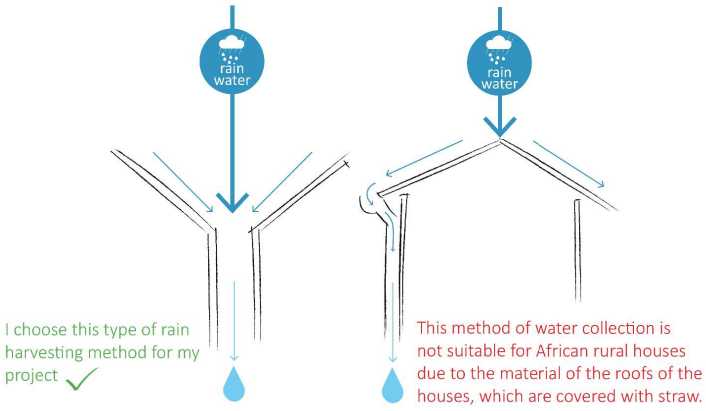
In rural areas of Africa, infrastructure is scarce, and building a well is neither easy nor affordable. To find water source, they need to drill deep in the ground up to 1,600 ft (500 m). Bringing water to the top requires pumps and electrical equipment, which are both expensive and difficult to maintain.

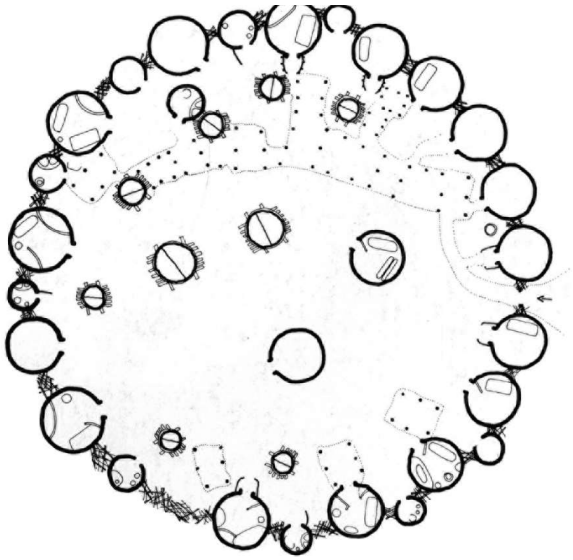
In african countries at least 25% of the population spends more than 30 minutes on a round-trip to collect water.

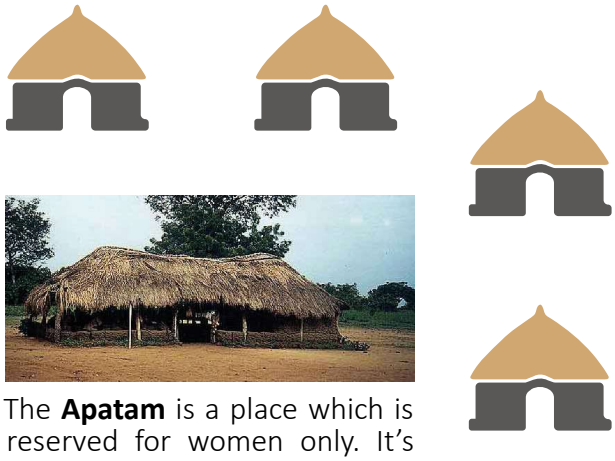
polluted Surface water sources.

According to the existing conditions of these areas, I suggest rainwater harvesting for these villages.

These two type of design have been the most popular methods for rainwater harvesting:







The **Apatam** is a place which is reserved for women only. It's a kind of pavilion made of logs and a straw roof.

The village square, the "stomach" of the body, lies in the middle. Children play in the shade of the trees. In the evening, the elders hold their conventions and discuss difficult decisions. This is where celebrations and religious rituals are also held.

Based on the above, the project I have chosen is very similar to the Warka tower project, which means it has an architectural structure to collect rainwater. For this purpose, I have tried to deal to the problems that have been indicated as weaknesses in Warka water.

Here I will try to examine more of these cases:

Figure 107: Warka Tower, version n. 3.2

- Today the Warka Water prototype in Dorze sits in a small heap on the site, long abandoned by the research team and the people. From what could be seen, the remaining items on site are the polyester net and the 3,000-litre water tank, while most of the bamboo had collapsed due to weathering.

According to residents, the structure remained in place for almost 11 months after the inauguration. Unfortunately it finally collapsed mainly due to general neglect and absence of ownership. Though a fence had been added after monitoring activities, animals and children venturing into the fenced area and tampering with the structures and ropes continued[159].

The communities of Dorze tell stories of hope that was promised and not fulfilled through the Warka Water project. They were excited and hopeful that their some of their water problem would be solved as explained to them by the architect and his team, and today are rather disappointed that this did not come about and the project was abandoned. Water still remains a scarce commodity

159 R. Shawl, 2019 On Site Review Report Warka Water, Dorze, Ethiopia

to the residents of Dorze.As we have seen before, the next generations of Warka have tried to solve this problem and the structures aren't light just like before.

Figure 108: The structure remained for around 11 month before it collapsed. It is mainly due to a lack of maintenance.

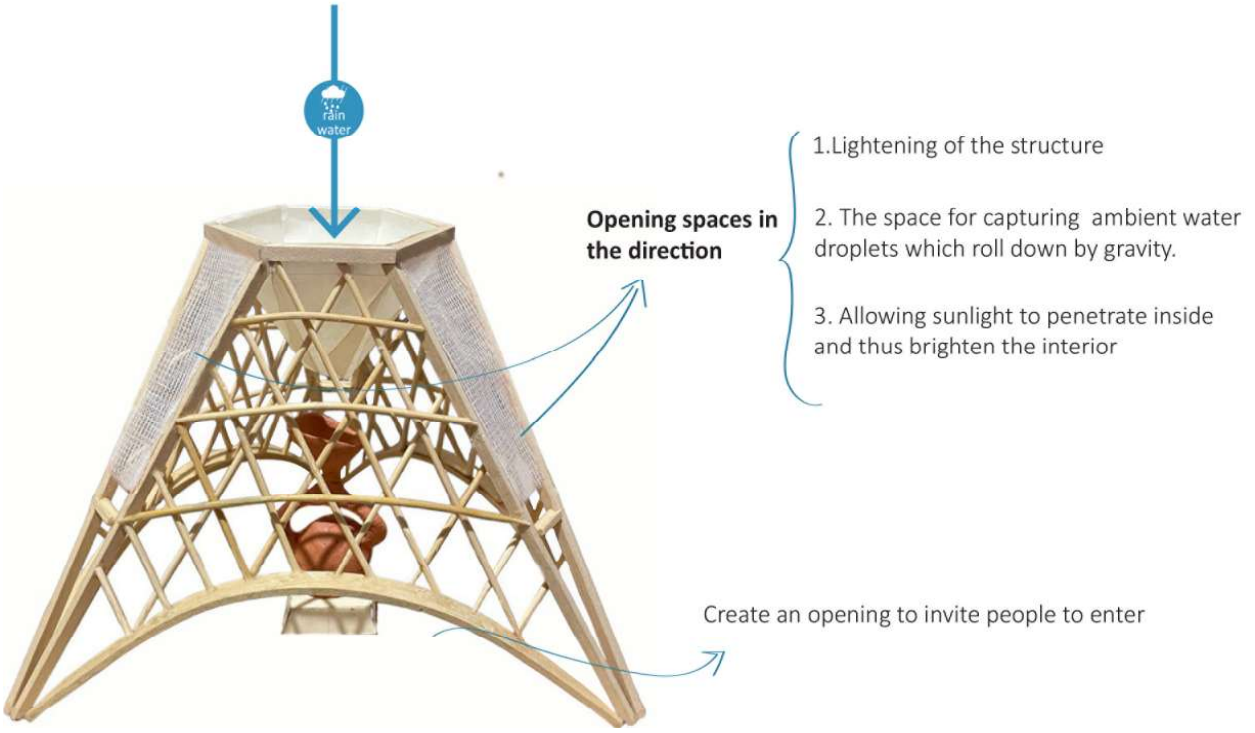
But these projects aren't like warka 3 to have a suitable space for gathering of village people, and instead , they are only designed for collect rainwater.

Figure 109: The Warka Tower, version n. 4.1, has been constructed in Cameroon
https://warkawater.org/

Figure 110: The Warka Tower, version n. 4.2, Cameroon
https://warkawater.org/

Figure 111: Tap water, the place to collecting water
https://warkawater.org/

Figure 112: Dark space inside of Warka 4.1
https://warkawater.org/



7.2 GOALS

The tower is designed to collect water from rainwater, the air and fog.

Is an alternative water source for rural populations that face challenges in accessing drinkable water. Where infrastructure doesn't exist and communities are isolated. Can collect and store water from air to survive in hot weather. if there was a way to make purified water more accessible, so women could take care of their homes and so children could get an education, without disturbing the natural landscape.

The shade and good indoor air allows the tower to serve as a gathering place.

7.3 FUNCTION

This project consists of several parts, which we will deal with in order:

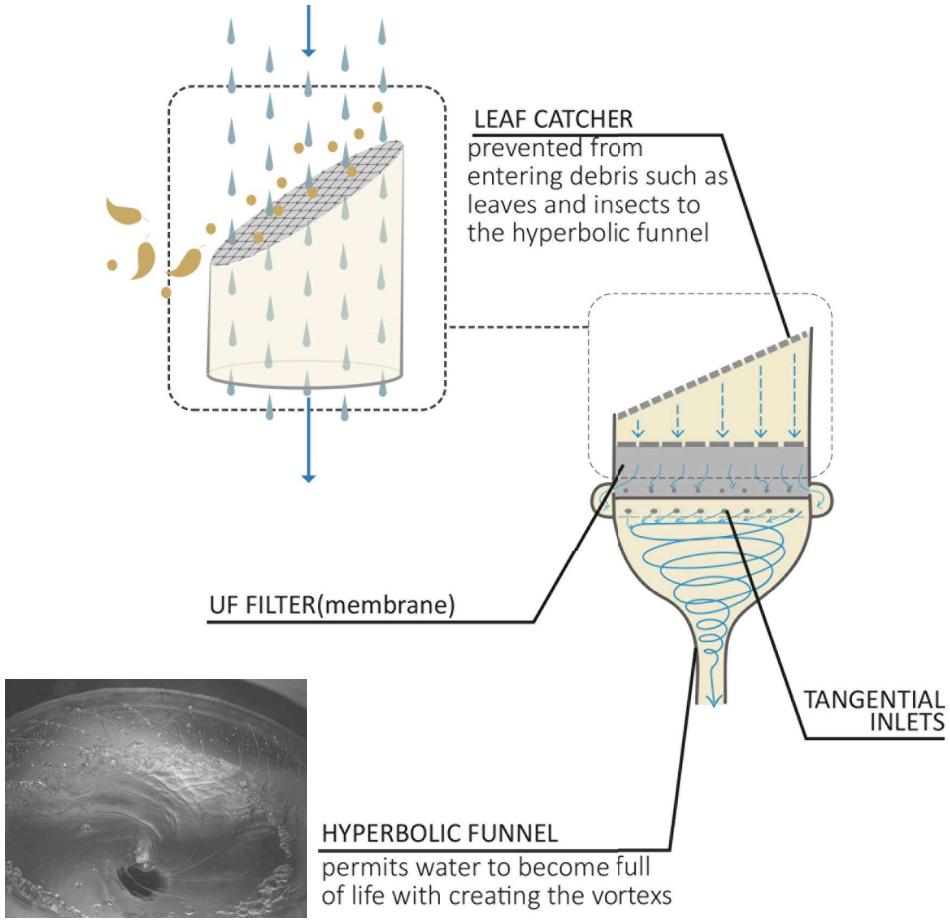
Rainwater Harvesting system

1. FUNNEL: This collector is a large funnel of a waterproof canopy, that is responsible for collecting and directing rainwater.

2. LEAF CATCHER: Stainless steel filter mesh that prevented from entering debris such as leaves and insects to the hyperbolic funnel

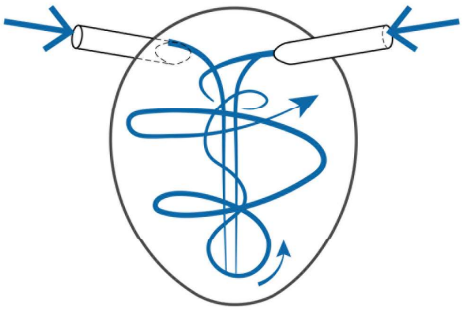
3. UF FILTRATION: Various factors affect the quality of harvest rainwater. Including PAH(polycyclic aromatic hydrocarbon), which occurs in urban environments due to air pollution, and NO_2, which is obtained from fossil fuels, fortunately are not considered in this project because our topic is in rural African environments. But the presence of bacteria such as Coliform bactery greatly affects the quality of water (this bacteria is found in the feces of warm-blooded animals). From this point of view, there is a need for a filter for this water. For this purpose, I suggest Ultrafiltration(membrane)

4.HYPERBOLIC FUNNEL: At this stage, the filtered water enters the funnel through tangential inlets. These holes are located around the funnel and help create a vortex flow inside the funnel. as a result permits water to become full of life.



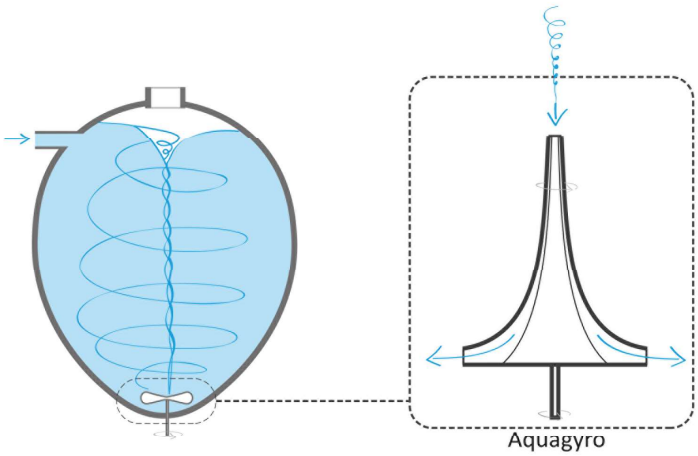
5.STORAGE TANK: Water tangentially enters to storage through two pipes, which are placed at the bottom of that an aquagyro to create vortices in the tank.

- Water loses its quality of life when it is storage vessel that is square shape
  Where it unable to move due to the corners. It becomes stale, no longer refreshing, and no longer able to cleanse itself.
- Viktor Schauberger believed that the ovoid shape was optimal for containing water.



Tangential inlet diagonally from above

Ovoid matrix generating a clockwise columnar vortex in free flow in its center which induces a very powerful kinetic energy in the heart of the egg



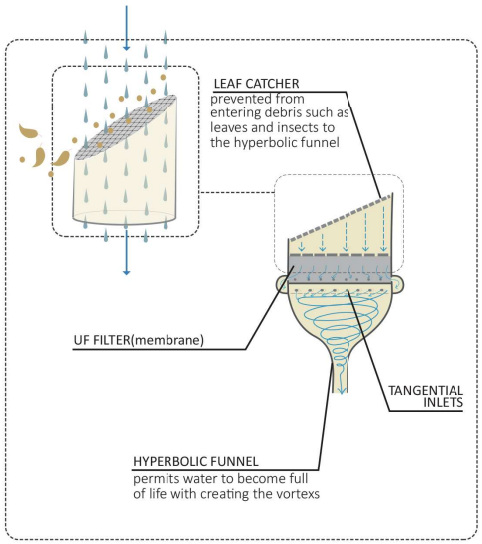
When water remains stationary for a few days it will lose its vitality for avoiding that, there is Aquagyro that rotate in the storage for give a movement to the water:

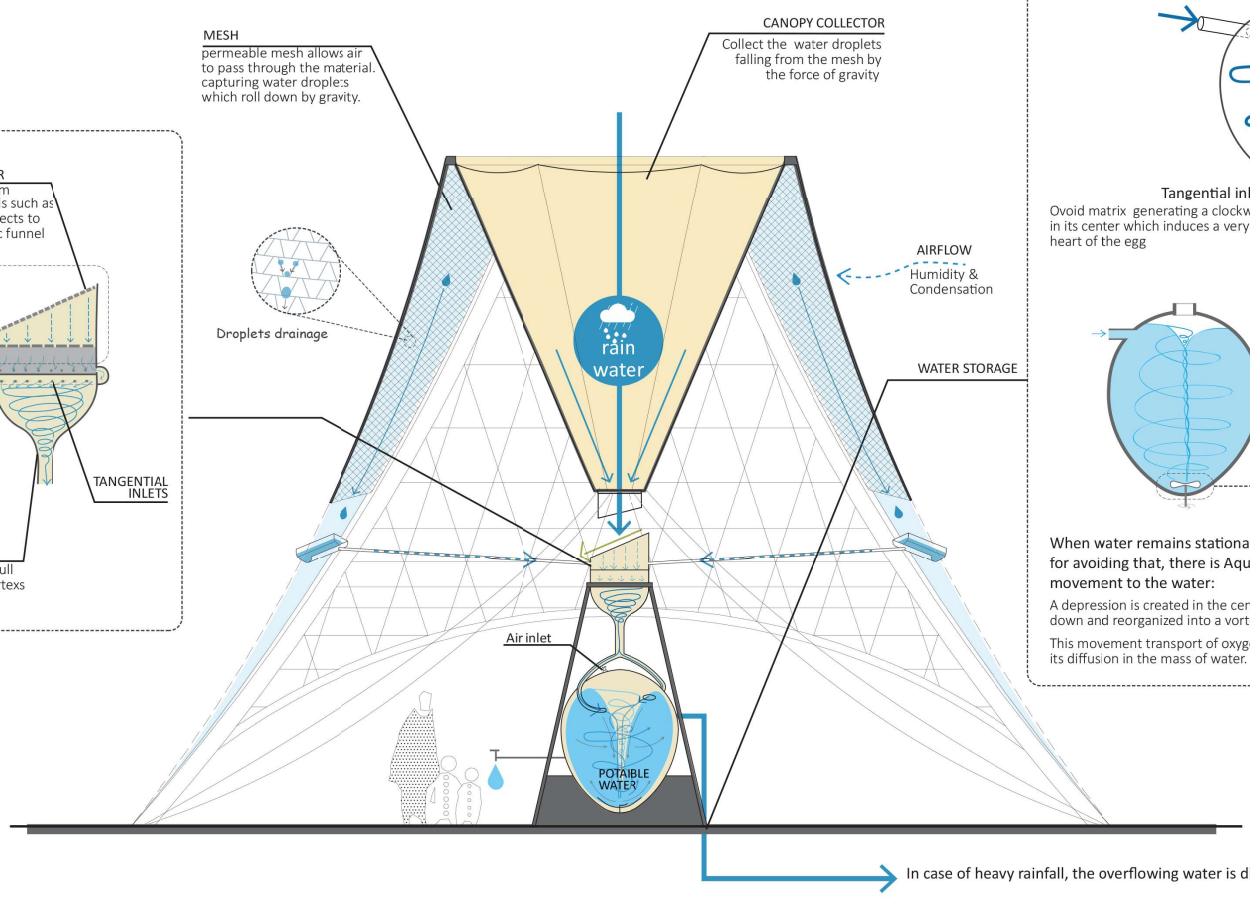
A depression is created in the center and the water is sucked down and reorganized into a vortex.

This movement transport of oxygen downwards and therefore its diffusion in the mass of water.

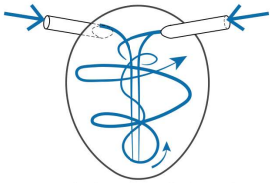
FOG & DEW HARVESTING

As shown in the model, put nylon mesh between the beams of the structure. Outside, a case allows air to pass through, while inside a nylon mesh collects the dew drops on the surface. The difference in temperature between day and night creates condensation that slips into a gutter and the water reaches through the pipes to the storage tank.



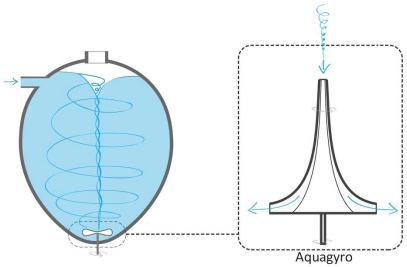


- Water loses its quality of life when it is storage vessel that is square shape
  Where it unable to move due to the corners. It becomes stale, no longer refreshing, and no longer able to cleanse itself.
- Viktor Schauberger believed that the ovoid shape was optimal for containing water.



Tangential inlet diagonally from above

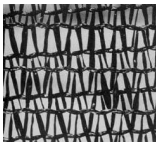
Ovoid matrix generating a clockwise columnar vortex in free flow in its center which induces a very powerful kinetic energy in the heart of the egg



When water remains stationary for a few days it will lose its vitality for avoiding that, there is Aquagyro that rotate in the storage for give a movement to the water:

A depression is created in the center and the water is sucked down and reorganized into a vortex.

This movement transport of oxygen downwards and therefore its diffusion in the mass of water.

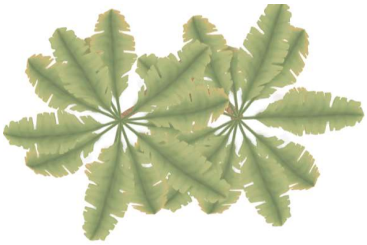


Dew collectionby **nylon mesh** can be achieved by passing the humid ambient air over a cooled surface, and condensed liquid water is obtained if the surface temperature is lower than the dewpoint temperature of air.

During the day, as temperatures rise outside, the heat makes water evaporate from the plants inside . At the end of the day, the water condenses into dew and rolls back into a collection tank.

Palm leaves are used because they are so plentiful and because they are innately suitable for roofing.

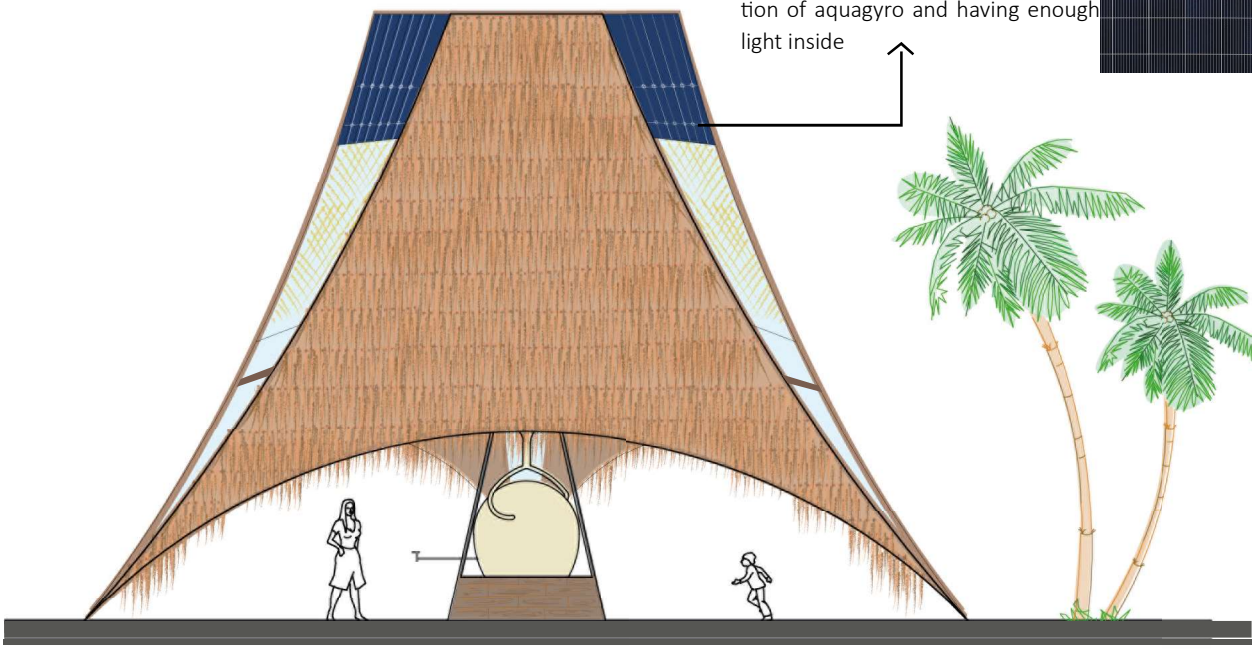
This cover is considered as a suitable insulation to prevent heating of the space under the shader. Thus, it is a suitable place to place the egg-shaped water tank.



ROOF PLAN

SC:1/100

Using **solar panels** to provide the necessary electrical energy for rotation of aquagyro and having enough light inside

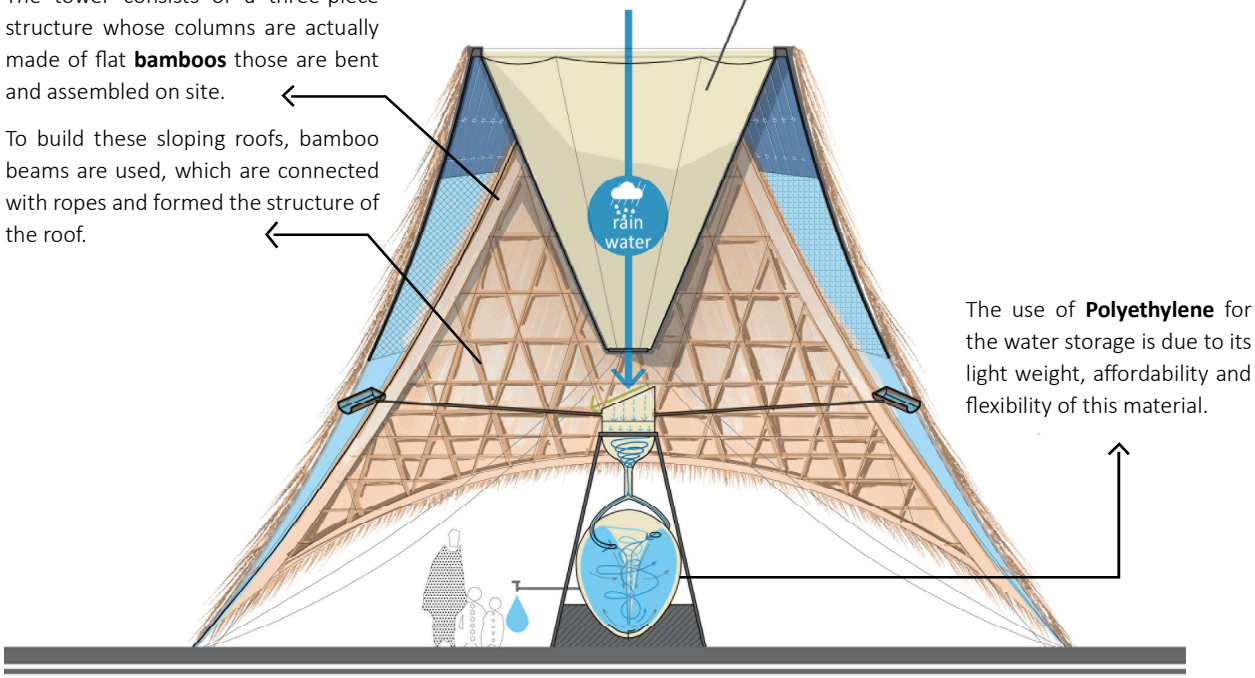


SOUTH ELEVATION

SC:1/100

The tower consists of a three-piece structure whose columns are actually made of flat **bamboos** those are bent and assembled on site.

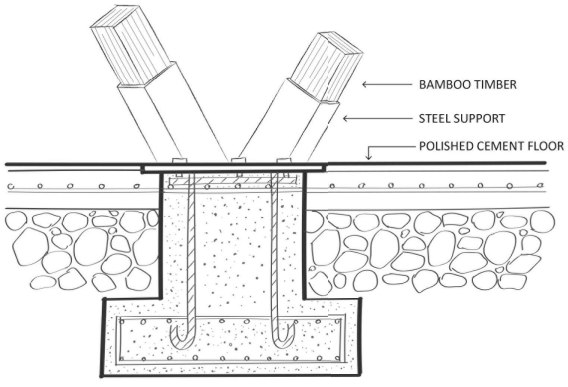
To build these sloping roofs, bamboo beams are used, which are connected with ropes and formed the structure of the roof.



SECTION A-A

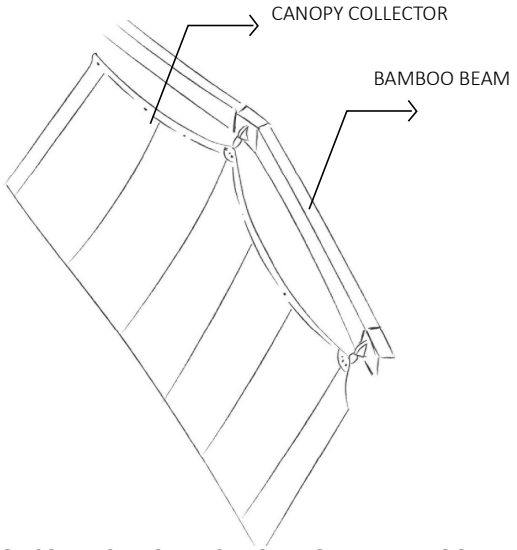
SC:1/100

7.5 DETAILS

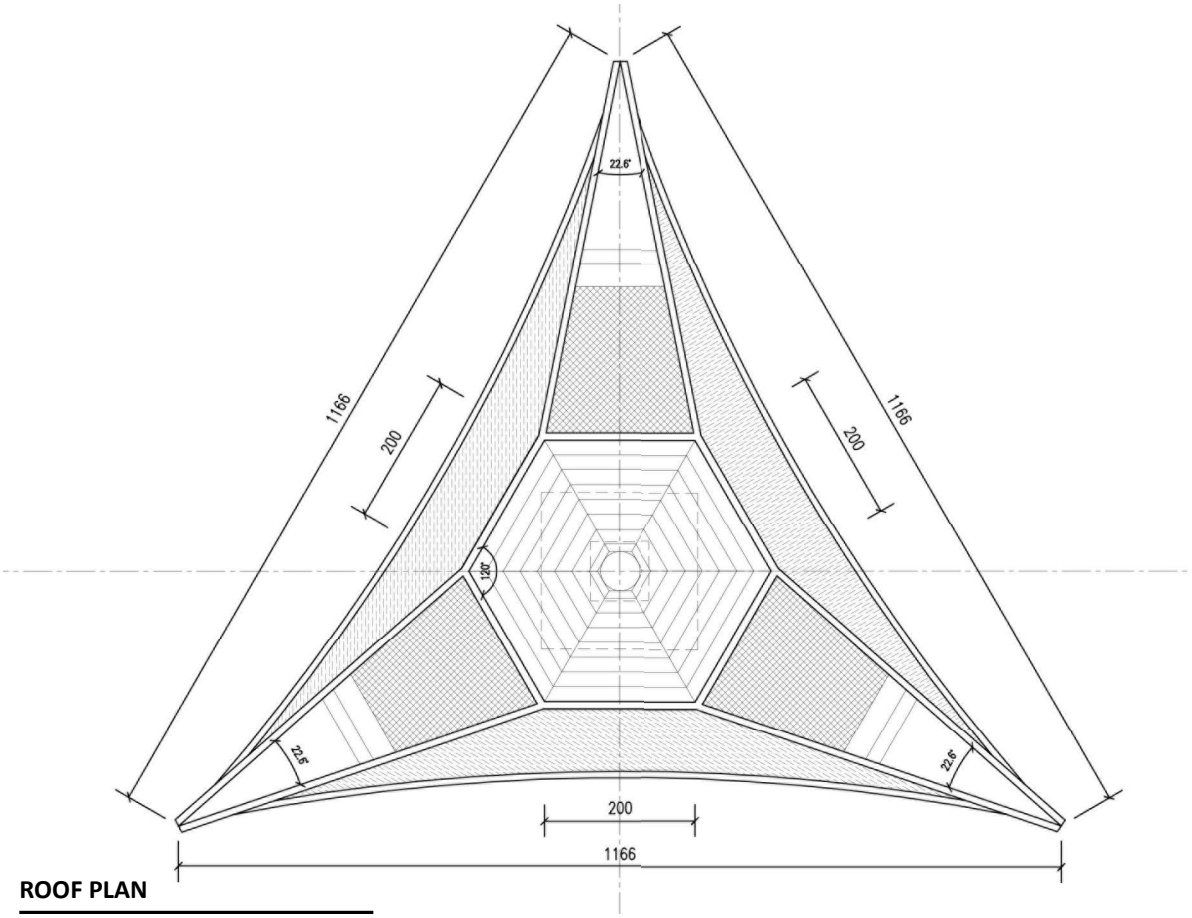


FONDATIONS DETAIL SECTION

SC:1/20

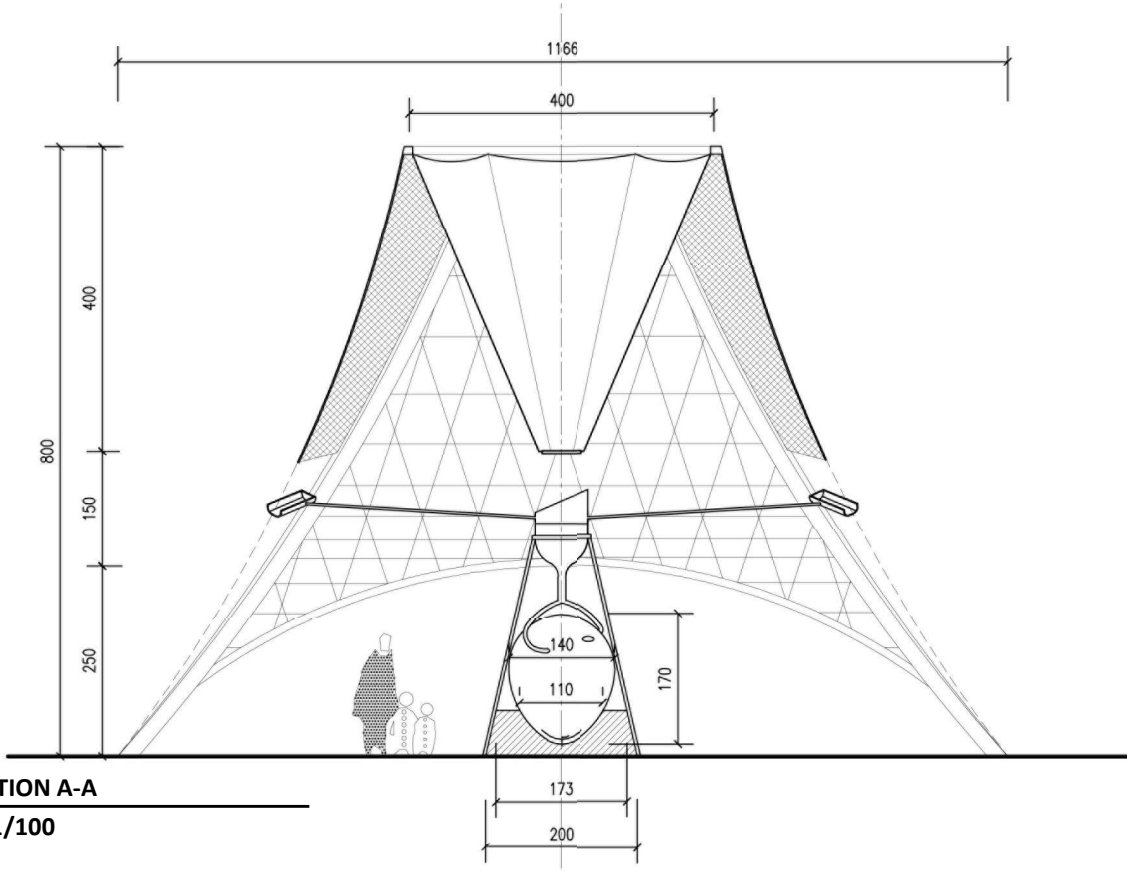


DETAIL OF CONNECTING THE CANOPY TO THE BAMBOO BEAM



ROOF PLAN

SC:1/100



SECTION A-A

SC:1/100

8. BIBLOGRAPHY

Abbas SH, Ismail IM, Mostafa TM, Sulaymon AH. Biosorption of heavy metals: A review. Journal of Chemical Science and Tech-nology. 2014

A.Cain, Chokwe Traditional Architecture (Angola, NE) Encyclopedia of Vernacular Architecture of the World, Volume 3-VII-2-g p2002, Cambridge UP , October 2018

Adelia Bretetto, Homage to Viktor Schauberger, Viktor Schauberger a great precursor with a deep passion: water, Brussels, 5th April 2000

AF. Jivala Daniel Traditional Architecture in Angola Sustainability Strategies, May 2019

Alick Bartholomew, Hidden Nature, The Startling Insights of Viktor Schauberger, 14 Nov 2013,
Alley ER. Water Quality Control Handbook. Vol. 2. New York: McGraw-Hill; 2007

A.Picard, R. S. Davis, M. Gläser and K. Fujii, Revised formula for the density of moist air (CIPM-2007) Metrologia 45(2008),
APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. Washington, DC: American Public Health Asso-ciation; 2005

Aquagyro AB, Pilotanlaggning i Alvsbyn Information brochure from Aquagyro AB, Umea 1991

Arlis hispania s.l, Crystallization analysis quality of water from purification units evaluation,20 march 2012

Aristotle. “Book I 983b”. Aristotle, Metaphysics. Perseus Project.

Aristotle, (2014). “Complete Works of Aristotle, Volume 1: The Revised Oxford Translation”, p.582, Princeton University Press

AWWA. Water Treatment Plant Design, 3rd edn. McGraw-Hill, 1998

Ball HL. Nitrogen reduction in an on-site trickling filter/upflow filters wastewater treatment system. In: Proceedings of the 7th International Symposium on Individual and Small Community Sewage Systems, ,American Society of Agricultural Engineers, 1994.

Boysen JE, Harju JA, Shaw B, et al. The current status of commercial deployment of the freeze thaw evaporation treatment of produced water.
In: SPE/EPA Exploration and Production Environmental Conference. Austin, TX, SPE 52700, 1999, 1–3.

Cassidy AL. Advances in flotation unit design for produced water treatment. In: SPE 25472 Production Operations Symposium, Oklahoma, 1993.

Callum Coats, Living Energies, Viktor Schauberger ‘s Brilliant work with Natural Energy Explained, (July 5th 2001 by Gill &Mac Millan)

Caraka 1.27 (translated in Sharma, Caraka-samhita, vol. 1, 211–12).

Chatterjee A. Water Supply Waste Disposal and Environmental Pollution Engineering (Including Odour, Noise and Air Pollution and its Control). 7th ed. Delhi: Khanna Publishers; 2001

Cothern CR. Radon, Radium, and Uranium in Drinking Water. Boca Raton: CRC Press; 2014

Colorado School of Mines. Technical Assessment of produced water treatment technologies. An Integrated Framework for Treatment and Management of Produced Water. RPSEA Project 07122-12, Colorado, 2009

C¸ akmakce M, Kayaalp N, Koyuncu I. Desalination of produced water from oil production fields by membrane processes. Desali-nation 2008

Clifford DA. Ion exchange and inorganic adsorption. In Letterman RD(ed.). Water Quality and Treatment. McGraw-Hill, 1999.

Collelo, Thomas, ed. (1989). Angola: a country study. Washington, D.C.: Federal Research Division, Library of Congress. pp. 57–61. OCLC 44357178. Archived from the original on 8 April 2022. Retrieved 19 June 2022.

Davis ML. Water and Wastewater Engineering—Design Principles and Practice. New York: McGraw-Hill; 2010

Davis ML, David A. Introduction to Environmental Engineering. 4th ed. New York: McGraw-Hill Companies; 2008

Daniel Arthur J, Langhus BG, Patel C. Technical Summary of Oil & Gas, Produced Water Treatment Technologies. NETL, 2005
Department of Atomic Energy, Bhabha Atomic Research Centre, Desalination & Water Purification Technologies, 2010

DeZuane J. Handbook of Drinking Water Quality. 2nd ed. New York: John Wiley & Sons; 1997

Die Wasserwirtschaft, No. 24, 1930.

Dr Joachim Schwuchow PhD, John Wilkes ARCA, Prof. Costantino Giorgetti Eng, Iain Trousdell BA, Iain Trousdell BA, Alison Trousdell BA, FLOWFORM WATER RESEARCH, A Collation of Research and Related Ideas, Healing Water Institute, 1970-2007

Dr.Svante Arrhenius received the 1903 Nobel Prize in chemistry for the development of ionic theory, which he applied to the def-inition of acids and bases.
DeZuane J. Handbook of Drinking Water Quality. 2nd ed. New York: John Wiley & Sons; 1997

E.g., Caraka 1.5 (translated in P. V. Sharma, Caraka-samhita, [Varanasi: Chaukhambha Orientalia, 2007–2008], vol. 1)

EPA. Onsite Wastewater Treatment and Disposal Systems Design Manual.US EPA, 1980.

Energy & Environment Research Center. Free-Thaw. 2010. Retrieved 10 June 2011.

Faibish RS, Cohen Y. Fouling-resistant ceramic-supported polymer membranes for ultrafiltration of oil-in-water micro-emulsions. J MembrSci 2001

Frokjaer-jensen, Borge, Advances with Viktor Schauberger's implosion system , Ottawa, 1988

Godshall NA. AltelaRainSM produced water treatment technology: making water from waste. In: International Petroleum Envi-ronmental Conference, ALTELATM, Houston, TX, 2006

Hazen Drive, Reverse Osmosis Treatment for Drinking Water, New Hampshire, 2009

He Y, Jiang ZW. Technology review: treating oilfield wastewater. Filtr Sep, 2008

Jain Irrigation Systems Ltd. Sand separator—Jain hydro cyclone filter,2010.

John D.Hem, Study and Interpretation of the chemical characteristics of Natural Water, United States goverment printing office, 1985

Johann Wolfgang von Goethe (1882). "The Poems of Goethe", Richard West

Judd S, Jefferson B. Membranes for Industrial Wastewater Recovery and Re-use Oxford. Elsevier Ltd, 2003

Kadik, A. A., E. B. Lebedev, and N. I. Khitarov. Voda v magmaticheskikh rasplavakh. Moscow, 1971

Kahn, C. H., 1979, The Art and Thought of Heraclitus, Cambridge: Cambridge University Press. Laks, André and Glenn W. Most, 2016, Early Greek Philosophy, vol. 3, Cambridge, Mass.: Harvard University Press.

Khemakhem S, Larbot A, Ben Amar R. New ceramic microfiltration membranes from Tunisian natural materials: application for the cuttlefish effluents treatment. Ceram Int 2009

Lars Johansson, Morten Ovesen, Curt Hallberg, Self-organizing Flow Technology- in Viktor Schauberger's Footsteps, Institute of Ecological Technology Scientific and Technical Reports – 1, Malmo – Sweden – 2002

Mara D, Horan NJ. Handbook of Water and Wastewater Microbiology. London: Elsevier; 2003

Madaeni SS. The application of membrane technology for water disinfection. Water Res 1999
McGhee TJ, Steel EW. Water Supply and Sewerage. New York: McGraw-Hill; 1991

M. J. Figueras and J. J. Borrego, "New perspectives in monitoring drinking water microbial quality," International Journal of Envi-ronmental Research and Public Health, vol. 7, pp.4179–4202, 2010

MN 28, "Maha-hatthipadopama Sutta: The Great Elephant Footprint Simile," translated by Thanissaro Bhikkhu, accessed April 21, 2017, https://tinyurl.com/p933bv4 (edited for punctuation and clarity).

On the history and contents of this text, see Paul U. Unschuld, Huang Di Nei Jing Su Wen: Nature, Knowledge, Imagery in an An-cient Chinese Medical Text (Berkeley and Los Angeles: University of California Press, 2003).

Olof Alexandersson , Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan),

Olof Alexandersson, Kit Zweigbergk, Charles Zweigbergk, Living Water, Viktor Schauberger and the secret of Naural Energy, (March 7th 2002 by Gill & Mac Millan)

Patrik J.Sullivan, Franklin J.Agardy, James J.J.Clark, The Environmental Science of Drinking Water, 01 ago 2005

R. Shawl, 2019 On Site Review Report Warka Water, Dorze, Ethiopia

See Edward Schafer, "The Development of Bathing Customs in Ancient and Medieval China and the History of the Floriate Clear Palace," Journal of the American Oriental Society vol. 76, no. 2 (1956)

Schafer, "The Development of Bathing Customs,"

Schauberger thoroughly investigates this in Hydrotechnology, No. 20, 1930

S.-L. Loo, A. G. Fane, W. B. Krantz, and T. Lim, "Emergency water supply: a review of potential technologies and selection crite-ria," Water Research, vol. 46, no. 10, pp. 3125–3151, 2012

Spellman FR. Handbook of Water and Wastewater Treatment Plant Operations. 3rd ed. Boca Raton: CRC Press; 2013

Spellman FR. The Drinking Water Handbook. 3rd ed. Boca Raton: CRC Press; 2017

Skeppström K, Olofsson B. Uranium and radon in groundwater. European Water. 2007

Su D, Wang J, Liu K, et al. Kinetic performance of oil-field produced water treatment by biological aerated filter. Chin J Chem Eng 2007

Svarovsky L. Hydrocyclones: Analysis and Applications. Kluwer Academic Publishers, 1992

"Te Waikoropupū Springs". New Zealand Department of Conservation. Retrieved 6 February 2022.

Tchobanoglous G, Burton FL, Stensel HD. Metcalf & Eddy Wastewater Engineering: Treatment and Reuse. 4th ed. New Delhi: Tata McGraw-Hill Limited; 2003

Tchobanoglous G, Peavy HS, Rowe DR. Environmental Engineering. New York: McGraw-Hill Interamericana; 1985

The USGS Water Science School. United States Geological Survey. 23 May 2013. Retrieved 21 Jan 2014.

Tomar M. Quality Assessment of Water and Wastewater. Boca Raton: CRC Press; 1999

T.Teuscher1aJ.B.RosmancP.BaillodbA.Teuscherc, ABSENCE OF DIABETES IN A RURAL WEST AFRICAN POPULATION , Volume 329, Issue 8536, 4 April 1987,

UNESCO, Divisione Scienze dell'Acqua, Paris – France. Basics of Water Resources. Course Book. United Nations Environment Pro-grame – Vital Water Graphics: An Overview of the State of the World's Fresh and Marine Waters, second edition, 2008

United States Environmental Protection Agency (2017-11-02). "Fresh Surface Water". US EPA. Retrieved 2020-04-06.

U.S Department of the Interior. "Surface-Water Use". www.usgs.gov. Retrieved 2020-04-06.

U.S. Bureau of Reclamation. Desalting Handbook for Planners, 3rd edn. Desalination and Water Purification Research and Devel-opment, Program Report No. 72, 2003

Viktor Schauberger, Implosion Magazine, No. 36

Viktor Schauberger, Callum Coats, The Energy Evolution, harnessing free energy from nature, (5th October 2000)

Verein für Implosionsforschung,Spiral pipe in accordance with E. Neumann,Klaus Rauber

World Health Organization. Guidelines for Drinking-Water Q , Vol. 2, Health criteria and other supporting information. 1996

"What is Groundwater? | International Groundwater Resources Assessment Centre". www.un-igrac.org. Retrieved 2022-03-14.

Xu P, Drewes JE. Viability of nanofiltration and ultra-low pressure reverse osmosis membranes for multi-beneficial use of me-thane produced water.Sep Purif Technol 2006

http://phaelosopher.com/2010/10/31/a-real-life-clinical-trial-opportunity-for-mms/

http://createtodiscover.com/water/section4.php

https://en.wikipedia.org/wiki/Properties of water

https://en.wikibooks.org/wiki/Structural Biochemistry/Unique Properties/Polarity and Hydrogen Bonding

http://www.metafysica.nl/ontology/general_ontology_29c.html

https://en.wikipedia.org/wiki/Rain

http://chestofbooks.com/food/beverages/A-Treatise-On-Beverages/Properties-And-Tests-Of-Distilled-Water.html#.VbYE4_ntnxp

https://en.wikipedia.org/wiki/Jacques_Benveniste

https://sites.google.com/site/appliedmemwaterresearch/jacques-benveniste

http://waterprojectlondon.over-blog.com/article-ii-2-desalinisation-59096927.html

http://schauberger.co.uk/

http://www.newphysics.se

https://www.alivewater.com/viktor-schauberger

http://theartofnature.org/id20.html

http://www.disclose.tv/forum/the-third-reich-the-vril-gizeh-intelligence-t61692-10.html

http://www.implosion-ev.de/

http://www.aquatechnology.net

https://www.vibrancywater.ca/index_files/structured_water_unit_About_Structured_Water.htm

https://rafiufishbone.blogspot.com/

https://thirdeyemom.com/

https://climateknowledgeportal.worldbank.org/

https://www.britannica.com/