WATER PURIFICATION SYSTEM IN RURAL AREAS

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Abstract - The population of developing countries experiences a lack of adequate sanitary conditions, including drinking water that meets their basic needs. Water purification is the transformation through which vital liquid passes by generating water for human and animal consumption without risk to disease.
The most important basis of life on earth is water, without which it is difficult to survive. The human population has remained for thousands of years. But today, very few areas of the planet are saved from water pollution. Only 3 percent of the earth's water is sweet rather than salty and 99% of this is under deep ground or exists as glaciers or ice sheets.
Water pollution today is a major challenge as most economic activities are used by water. Some estimates conclude that 75 per cent of countries do not have access to safe drinking water.
The proposed water treatment system consists of a rain collector and a water treatment plant involving operations such as: debasing, coagulation and flocculation, filtration, absorption with activated charcoal, chlorination and reverse osmosis.

Keywords - Water Treatment, Biofiltration, Break Point, Bio-sand

I. INTRODUCTION

The most important basis of life on earth is water, without which it is difficult for humans to survive and also to carry out economic activities. The human population has been maintained for thousands of years due to complex water interactions with the rest of the natural environment. But today, very few areas of the planet are saved from water pollution. Only 3 percent of the earth's water is sweet rather than salty and 99% of this is under deep ground or exists as glaciers or ice sheets. This small proportion of available fresh water would, however, be sufficient to meet the needs of the planet's human population, if only shared more equitably, and current levels of waste, as well as water and wetland damage, were addressed. (Lanz, 1995)

There are a number of environmental problems facing developing countries, but the most crucial environmental problems are water pollution, air pollution and soil degradation. Water pollution today is a major challenge as most economic activities are used by water. Some estimates conclude that 75 per cent of countries do not have access to safe drinking water. (Bhagirath, 2002)

Drinking water quality is a global problem. Today, there is a growing tendency for fresh water to be under immense strain due to rapid population growth, urbanization and unsustainable water consumption in industry and agriculture. (Ding, and others, 2016)

Water pollution is mainly caused by industrial pollution. Landfill water effluents contain chemicals and biochemicals that impose high demands on oxygen in water with low dissolved oxygen (OD) levels, high biochemical oxygen demand (BOD), and chemical oxygen demand (DQO), and high level of TDS (total dissolved solids). There are certain components in water such as chemicals and heavy metals, such as arsenic, lead, mercury, cadmium, zinc, etc., harmful to health and ecosystem. Contaminated water also has a serious impact on land productivity. Large concentrations of chemicals and metals, both on the surface and in bodies of groundwater, cause serious damage to the ecology of river systems. Drinking water should not have water, such as microorganisms, organic waste, acids, bases, heavy metals and other industrial chemicals.(Chan, 2001) (Sengupta, 2006.)

In the face of the need for rural communities and the lack of clean water, research into new water purification alternatives, alternatives that are economical and help the demand for water for domestic use, must be used. Water treatment arises as an option, for the provision of water with good quality. The most commonly used technique in water treatment plants is aluminum sulfate, which is questioned as they show that its residues cause neurodegenerative diseases. There are also treatments that help to improve this problem that are: Biofiltration this method uses a single operation for water purification, they are aided in physical and biochemical processes as a result of low filtration rates, which are generated by the formation of a biolayer on the surface of the bed, it is responsible for stopping and eliminating pathogens. (Ruiz, 2004)
We also have the method of efficiency of The Oil Moringa seed as a natural coagulant for the removal of turbidity, it has been found that the active component of the oily M. seed that causes the coagulation of raw cloudy water with a soluble protein that reacts in the process as natural cationic polyelectrolyte. Protein coagulation is increased in the implementation of inorganic salts in extract. The purification of active substances of the oily M. coagulant obtained with saline solution does not increase the residual organic concentration of water

after coagulation. Natural coagulants are economical and biodegradable as they can be grown and have an effective dosage in the flocculation of colloidal suspensions. The oily Moringa seed by its natural principle is transformed into a good method for the elimination of microorganisms and turbidity that are suspended in the water of lakes and rivers that are the water sources used in rural communities or where there is no drinking water network. Experiments with Moringa oleifera seed have confirmed that it discards high levels of color and turbidity. (Barth, Habs, Klute, Muller, & Tauscher, 1982)(Okuda, Baes, & Nishijima, 2001)(Sanghi, Bhattacharya, & Dixit, 2006) (Santos, 2018)

Another method to obtain pure water from an alternative filtration system. This is done through the construction and monitoring of an unarmed prototype of water treatment for rural areas called the Treatment Tower helps clarify and filter, using granular materials such as: pumice stone, sand, gravel and activated charcoal, this offers safe water for rural areas that supply water from rivers (Camilo A. Torres-Parra, 2017)

This article will review and analyses different water purification processes that are: biofiltration, treatment tower, olifera moringa seed for turbidity removal and water treatment filter these are methods that can be used in rural areas as alternatives that guarantee a basic sanitation state suitable for the affected populations, thus improving their quality of life.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

The methodology chosen for this paper is of an investigative nature and of scientific revising because there are several autonomous articles in which several treatments for water purification are written, which are in such a way are totally dedicated to explain the transformation through which the vital liquid or water resource passes generating water for human and animal consumption without risk to diseases. The term water treatment has come since ancient times because since time in memorable it is a great problem for which human beings have felt affected, especially those who live in distant or ruralareas.

2.1. Unitary Processes for Water Treatment according to Its Pollutants

Water purification treatments can be carried out according to the type of contaminant present, in this sense, a list of unit processes necessary for water purification can be carried out depending on its components. In this way, the classification would be as follows. (Minor, 2012)

Table 1

UNIT PROCESSES USED FOR EACH TYPE OF CONTAMINANT

TYPE OF CONTAMINANT	UNIT OPERATION
Thick Solids	Roughing
	Coagulation
Colloidal Particles	Flocculation
	Decanting
Solids in Suspension	Filtration
Organic Matter	Active Coal Afino
Ammonia	Chlorination to BreakPoint
Pathogenic Germs	Disinfection
Heavy Metals (Fe,Mn)	Precipitation by Oxidation
Dissolved Solids(Cl-,Na+,K+)	Reverse Osmosis

Source: (Minor, 2012)

Some Unit processes that help treat water for human consumption can be detailed below.

2.1.1. Roughing

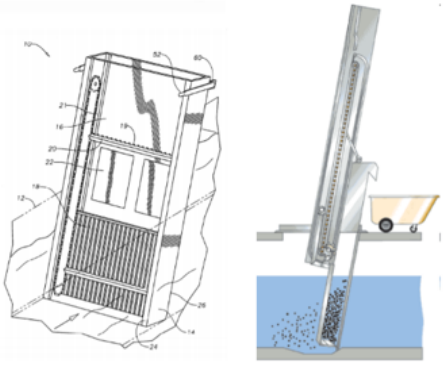
It is carried out by bars whose purpose is to retain bulky and suspended objects of a certain size that are swept away by water. There are different types of bars, being able to sort according to different criteria: (Perez de la Cruz Francisco, 2017)

a) Depending on the horizontal, vertical or inclined inclination

b)Depending on the separation between fine bars (< 1.5 cm), stockings (between 1.5 and 5 cm) and thick (between 5 and 15 cm) 1.5 and 5 cm) and thick (between 5 and 15 cm)

c) Depending on the type of manual or automatic cleaning

FIGURE 1
SLOPING BARS FOR TREATMENT FOR DESBASTE



Source: (Perez de la Cruz Francisco, 2017)

2.1. 2. Coagulation and Flocculation

Coagulation-flocculation is a chemical water treatment technique that is applied before a physical separation process that is usually done by sedimentation or filtration, in order to improve its particle removal capacity. Coagulation neutralizes loads and forms a gelatinous mass that traps particles, while flocculation gently moves such particles,

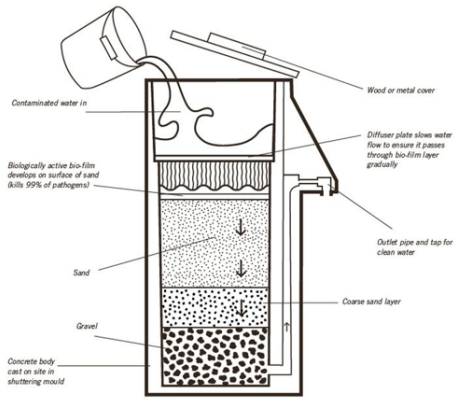
forming larger masses that sediment more easily. A main sale of the process is that it separates many types of particles from water since it improves the filtration process, while a major disadvantage is that it transfers toxic compounds to solid phase forming a mud that is subsequently treated. (Spuhler, 2011)

2.1.3. Filtration

In major filtration facilities, open filters exist, while closed filters are often used for small installations (less than 40m3/h). In water treatment stations, the porous medium is usually sand, sand + anthracite or active carbon in grain, and the suspended matter consists of flocs or microflocs from the previous stage of decanting. Filters in these installations are generally open, with filtration speeds between 6 and 15 m/h, with closed filters used under pressure in small installations (less than 50 m3 /h). (Vera, 2017)

FIGURE 2

FILTER TO WATER



Source: Pinterest (Vera, 2017)

2.1.4. Absorption with activated carbon

Adsorption is a process where a solid is used to remove a soluble substance from water. In this process the active carbon is the solid and is specifically produced to reach a very large internal surface area (between 500 - 1500 m 2 /g). (Lenntech, 2016)

Water is pumped into a column containing active carbon and the carbon activity of the column depends on the temperature and nature of the substances. Water passes through the column constantly, producing a buildup of substances in the filter. For that reason, the filter needs to be replaced periodically. (Lenntech, 2016)

2.1.5. Chlorination or Disinfection to Breakpoint

Chlorine is added to the water combined with organic and inorganic materials and some of the resulting chlorinated combinations, such as chlorophenols, can smell and are unpleasant. If the chlorine dose is increased, the combined residual will also increase and chlorine odors may increase. (Biscay, 2017)

Break point indicates complete oxidation of chloramines and other chlorinated combinations, and residual chlorine above the break point dose is mostly available free chlorine. (Biscay, 2017)

2.1.6. Precipitation by Oxidation

Phosphate prevents minerals from rusting and helps keep them in solution. Phosphate compounds must be introduced into the water at a point where iron is still dissolved in order to keep water clear and prevent stains. Injection should occur before the pressure tank and as close to the well discharge point as possible. Treatment by phosphate compounds is relatively inexpensive, but there may be disadvantages when using this method. (Vargas, 2018)

2.1.7. Reverse Osmosis

Reverse osmosis is a water purification technology that uses a semipermeable membrane to remove smaller ions, molecules and particles in drinking water. To achieve this, pressure is applied to overcome osmotic pressure, which is a co-limiting property produced by differences in the chemical potential of the solvent, a thermodynamic parameter. This process eliminates many types of suspended and ionized elements in water. (Verdesoto, 2017)

2.2. Water Treatments According to Quality Parameters

According to INEN 1128:2011, the parameters for drinking water in Ecuador are as follows:

Table 2
Drinking Water Requirements in Ecuador

PARAMETER	UNIT	Maximum Allowed Limit
Physical characteristics		
Color	Apparent color units (Pt - Co)	15
Turbidity	NTU	5
Smell	...	not objectionable
Taste	...	not objectionable
Inorganics		
Antimony. Sb	mg/l	0.02
Arsenic. As	mg/l	0.01
Barium Ba	mg/l	0.7
Borom. B	mg/l	0.5
Cadmium. Cd	mg/l	0.003
Cyanides. CN	mg/l	0.07
Residual free chlorine	mg/l	0.3 to 1.5 [1)]
Copper. Cu	mg/l	2.0
Chromium. Cr (total chromium)	mg/l	0.05
Fluorides	mg/l	1.5
Manganese. Mn	mg/l	0.4
Mercury. Hg	mg/l	0.006
Nickel. Ni	mg/l	0.07
Nitrates NO_3	mg/l	50
Nitrites. NO_2	mg/l	0.2
Lead. Pb	mg/l	0.01
Total radiation •	Bg/l	0.1
Total radiation •••	Bg/l	1.0
Selenium. Se	mg/l	0.01

Is the range in which the residual free chlorine must be for a minimum contact time of 30 minutes
Corresponds to the radiation emitted by the following radionuclides: ^{210}Po. ^{224}Ra. ^{226}Ra. ^{232}Th. ^{234}U. ^{238}U. ^{239}Pu
Corresponds to the radiation emitted by the following radionuclides: ^{60}Co. ^{89}Sr. ^{90}Sr. ^{129}I. ^{131}I. ^{134}Cs. ^{137}Cs. ^{210}Pb. ^{228}Ra

Source: (INEN 1128:2011, 2011)

According to the quality parameters set out in the Standard of the Ecuadorian Standardization Institute, treatments for water treatments can be classified into subgroups which will be detailed below.

2.2.1. Type A1: Simple physical treatment and disinfection

The aim of disinfection is to obtain water continuously free of pathogenic bacteria and germs, in accordance with official standards and trials based on Escherichia Coli, Fecal Streptococcals and Clostridium sulphite reducers. A contact time of at

least 20 to 30 minutes, being desirable to be 1 to 2 hours, with a dose of chlorine or residual chlorine dioxide of 0.05 to 0.2 mg/l is generally sufficient. Contact time and residual chlorine should be adjusted according to the water content in ammoniacal nitrogen, the nature of the disinfectant used and the eventual application of a pre-flowering. With the use of ozone, the contact time can be reduced to about 5 minutes, with the same residual dose as in the previous case, and without the dose to be added being influenced by ammoniacal nitrogen. It may also be of interest to take this disinfection beyond the official criteria and to target the total elimination of common germs, for this it is generally necessary to treat water with a much stronger disinfectant dose, resulting in a considerable free residual content. In the case of chlorine or its compounds, a dose higher than the critical point should be injected for a contact time of at least one hour. Free residual chlorine is a function of the nature of the water and germs to be removed. In the case of ozone, experience indicates that a dose such that at least 0.35 mg/l should be used for approximately 4 minutes. This criterion is the same as that followed for the destruction of viruses. Eliminate certain parasites such as the carrier of bilharciosis, for this you can practice a superchlorination. Superchlorination with a residual ozone dose of 0.9 mg/l may also be performed. The choice of disinfectant is a function of certain criteria, such as simple or complete disinfection, taste and economic problems. (Bajaña, 2015)

2.2.2. TYPE A2: Normal physical treatment, chemical treatment and disinfection

This treatment basically consists of two stages: coagulation and flocculation. The first is to get the colloidal and suspended materials in the water to form clots, through changes in polarity. During the flocculation phase these clots are agglomerate forming flocules, allowing their easy separation from the treated water. In the physical-chemical treatment of industrial wastewater, contaminant components not dissolved in water are separated without, in principle, altering the dissolved components. At least this is the concept commonly accepted in wastewater treatment technology. The truth is that when an addition of chemical reagents (coagulants, flocculants, pH neutralizers) the chemical structure is modified and precipitation occurs of components that were dissolved in the water. This chemical phenomenon is used, for example, for the elimination of iron and manganese by passing them to a oxidized form, or sulfates by adding a hydroxide, and to their subsequent precipitation at an appropriate pH. (Bajaña, 2015)

The main keys to good performance of a physical-chemical treatment are:

-Functional and highperformance design of the equipment.

-Balanced selection of the chemical reagent set, basically based on these four parameters: water clarification efficiency, reaction time, reagent costs and volume of generated sludge.

-Efficiency in the physical separation of the floccules from well-clarified water. (Bajaña, 2015)

2.2.3. TYPE A3: Intensive physical and chemical treatment, absorption and disinfection

Tertiary treatment is the most complete procedure for treating wastewater content, but it has not been widely adopted for being very expensive. The purpose of tertiary treatments is to eliminate residual organic load and other pollutants not eliminated in secondary treatments, such as nutrients, phosphorus and nitrogen. This treatment consists of a physical-chemical process that uses precipitation, filtration and/or chlorination to drastically reduce levels of inorganic nutrients, especially phosphates and nitrates of the final effluent. Wastewater receiving adequate tertiary treatment does not allow for considerable microbialdevelopment. (Bajaña, 2015)

Some available technologies are based on bio-arena filtration, one of which is biofiltration which is biological process used for the control or treatment of organic and inorganic volatile compounds present in the gas phase. It consists of a concrete or plastic container that is filled with sand and gravel, specially selected and prepared. As water flows through the filter, iron, turbidity and manganese are removed from drinking water by physical processes. In addition, pathogens are also eliminated by a biological process, when a gelatinous biological layer (biofilm) composed of non-harmful microorganisms that help eliminate pathogens develop at the top of the filter.(Luis Perez, 2020)

III. RESULTS AND DISCUSSION

According to the scientific review to have a good water purification system this should be simple and cost effective. Various treatments have been analyzed to remove contaminants in human consumption waterincluding; decanting and flocculation, which separates many types of particles from water and improves the filtration process, although the use of chemicals, qualified personnel for the design and constant maintenance of the system is required to ensure efficient treatment; In filtration to avoid jams it is important that particle retention is done inside the filter bed, and not on the surface of the bed, for this reason, it is important to make an adequate choice of the grain size of the filter bed; Break Point can be indicatedto indicate complete oxidation of chloramines and other chlorinated combinations and s i the dose of chlorines increased, the combined residual will increase as well and possibly increase chlorine odors; In precipitation by oxidation treatment by phosphate compounds is relatively inexpensive, but there may be

disadvantages when using this method, by adding a lot of phosphate can make the water feel slippery; In reverse hydrolysis theresult is that the dissolution is retained from the pressurized side of the membrane and the pure solvent can pass to the other side.

A technology highlighted in the water purification process is biofiltration that can be carried out in porous media or in granular media such as sand or anthracite,among others, allowing with the application of low filtration rates, the formation of a biological layer on the surface of the bed, which retains suspended particles and pathogenic microorganisms. The use of biosand filters is ideal for the safe treatment of water in homes, schools or even small communities and can be used both surface and groundwater. Forthe proper functioning of this filter, water should not have a turbidity value greater than 50 UNT, do not contain dissolved chemicals such as pesticides and zero presence of chlorine in the water to be filtered.

ACKNOWLEDGMENTS

Future demands of any population must be determined to provide for the design that meets the requirements, sources of supply, adduction lines, distribution networks, pumping systems, water purification systems and future extensions of the service; At the same time, careful study should be carried out to consider the economic possibilities of the community that guarantee the sustainability of the home system.

For the Decanting and Flocculation process, the concentration of chemical reagents (flocculants and coagulants) should be adequately adjusted to the exact composition of the water and maintenance work should be carried out regularly to ensure efficient treatment.

In The Treatment of Water treatment with Carbon the efficiency decreases by 5- 10% and if you work with various columns in series, you will not have a total depletion of the purification system;at the chlorination stage the smells of chlorine and other origin will disappear at the break point dose.

In oxidation precipitation treatment phosphate products are banned in some areas due to environmental concerns therefore it is not feasible to use this method.

The biofiltration process applied to wastewater treatment turns out to be a viable and adaptable alternative in different social sectors when using organic materials as a filter medium of the biofilm, taking into account optimal operational parameters to obtain high removal efficiencies and that is favorable in their arrangement, cost, operation and duration of biofilters.

Finally, it is noted that further research aimed at improving technology and processes is still needed for the optimization of such water treatment plants.

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