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PURIFICATION OF GROUNDWATER IN ARYAD PANCHAYATH: IRON AND E.COLI

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ABSTRACT

In a study conducted by Narayan, S (2020) to check the quality of groundwater in Aryad panchayath located in the coastal belt of Alappuzha district which lies in the coastal lowland division of Kerala, it was found that iron content is significantly high which imparts a rust color to the sample collected and makes it unfit for drinking. Also, the test confirmed the presence of E.coli bacteria. Overexposure to iron could lead to diabetes, result in loss of sex drive and potentially even lead to impotence. E.coli O157: H7 are dangerous, they can erode the lining of the small intestine and cause bloody diarrhea These two factors make the groundwater of Aryad panchayath unconsumable. The water must be treated sufficiently to eliminate pathogens and also to bring down iron content to an ideal amount which makes water consumable. After the review of some technologies to overcome this problem most efficient and economically feasible technology is recommended for purifying water in Aryad Pachnayath

1.0 INTRODUCTION

Aryad panchayath lies in the Alappuzha district in the southern part of Kerala which covers almost 687 km^2 of the district. The place has a total population density of about 9000/sq.mi. in the previous study groundwater of this place was tested according to Indian Standards. The samples were collected during November which represents the post-monsoon season of Aryad panchayath. The samples collected from an open well were filled up to the brim in a high-quality polyethylene bottle and was sealed and labeled systematically as per the standards recommended by the American Public Health Association (ADHA 1995). Various physicochemical and bacteriological parameters were tested by Water Care Laboratories located in Thrissur. The obtained results were compared with Indian Standards (IS) and with the World Health Organization (WHO).

Sl. No	Parameters	Unit	Acceptable Limit	Permissible Limit	Result
1	Ph	-	6.5-8.5	No relaxation	6.7
2	Turbidity	NTU	1	5	0.1
3	Total Dissolved Salts	mg/l	500	2000	170
4	Conductivity	µS/cm	400	-	304.6
5	Alkalinity	mg/l	200	600	68.4
6	Acidity	mg/l	-	-	7.3
7	Chloride (cl)	mg/l	250	1000	43.7
8	Total Hardness (CaCo3)	mg/l	200	600	40.5
9	Calcium (Ca)	mg/l	75	200	12.3
10	Magnesium (Mg)	mg/l	30	100	6.5
11	Iron (Fe)	mg/l	0.3	1.0	3.4
12	Sulphate (SO4)	mg/l	200	400	2.4
13	Coliforms	No.of coliforms in 100 ml	-	-	542
14	*E.coli*	No.of *E.coli* in 100 ml	-	-	present

Table 3.1 Test Results

The water collected from Aryad panchayath has the desired amount of chlorine, sulphate, ph turbidity, Total Dissolved Solids, Electrical conductivity. The iron content of the water is significantly high which not only imparts a rusty color to the water and makes it unfit for drinking but also promotes the growth of harmful microorganisms. As a result when tested the presence of E.coli bacterias was confirmed which makes water not fit for consumption and irrigation in Aryad panchayath. (Narayan, S., 2020)

2.0 METHODOLOGIES

The groundwater sample collected to check the quality from an open well in Aryad Panchyth of Alappuzha depicted the presence of undesirable iron content and E.coli bacteria in it. Due to this the water available in Aryad panchayath is not fit for irrigation and consumption. The excessive iron content in the water imparts a rusty color to the water and promote bacterial growth in which some are harmful to humans. When the human skin is subjected to water that contains excessive iron content, it could potentially clog up pores which result in skin breakouts and damaged skin cells. Undesirable content of iron entered into the human body through water could damage delicate organs and can indicate symptoms of iron poisoning which includes fatigue, weaknesses, joint pain, and abdominal pain. Overexposure to iron could lead to diabetes, result in loss of sex drive and potentially even lead to impotence. E.coli bacteria present in water cause brief diarrhea but strains such as E.coli O157:H7 are really dangerous, they can erode the lining of the small intestine and cause bloody diarrhea. They also cause stomach cramping, pain, and tenderness. In another angle, the risk is imparted to the production of leafy vegetables that are eaten raw without cooking. Irrigating these crops with water containing E.coli bacteria makes the edible part of the crop contaminated. Various water purification techniques for making iron level optimum in drinking water and for eradicating E.coli bacteria from the water of Aryad panchayath for making it fit for consumption and irrigation are reviewed in this journal.

3.0 LITERATURE REVIEW

3.1 Various Technologies for Removing Excessive Iron Content form Water

Oxidation-Precipitation-Filtration Process

Oxidizing soluble ferrous iron to insoluble ferric form results in precipitation of the iron percent in water. The precipitated iron is removed through a simple process of filtration. This process is the most conventional techniques used to remove excessive iron from drinking water. An oxidant is required to oxidize ferrous iron to ferric iron (E.A. Boyle and J.M. Edmond, 1997). Some of the generally used oxidants are hydrogen peroxide, chlorine, ozone, and chlorine dioxide. An optimal dose of the oxidants needed to be maintained during the treatment of water. Also, some studies have figured out that the iron removal efficiency of the process increase in pH and concentration of oxidant. (S. Vigneswaran and C. Visvanathan, 1995)

Zeolite Softening/ Ion Exchange

Iron exchange is the exchange of ions either cationic or anionic between two electrolyte solutions. In this procession exchangers such as zeolite play a major role. During the process of water treatment, the ion present on the exchanger is replaced with an unwanted ion present in the water. This is another widely used technique used to remove excess iron from water. Imino Diacetic Resin Purolite 3930 can be utilized for removing iron from water. At pH 5 the maximum amount of iron was removed from the water using this resin in a study(V. Shkolnikov and S.S. Bahga, 2012). Jordanian Natural Zeolite (JNZ) is also been used as an ion exchanger to remove excessive iron from water. This particular zeolite showed maximum iron removal efficiency at 303K, 40g/L dosage of the absorbent with a particle size of 45 mm. The contact time was in the range of 1-150 min and the sorption equilibrium was achieved between 1hr and 2.5hr. (L.D. Rollmann and E.W. Valyocsik, 1995)

Filter Media Separation

Generally, filter media is used to remove suspended particles such as clay, colloidal and precipitated natural organic substances, metal salt precipitates, and microorganisms. Sand, crushed anthracite coal, and granular activated carbon are also used as filter media(H.M. El-Naggar 2010). Aerated Anthracite which is used as a granular filter removed excessive iron from the water. But the iron removal efficiency of the filter decreased in the absence of aeration. Studies have shown that weakly acidic conditions (pH less than 7) favored the process. Iron being oxidized and precipitated on the filter media acts as catalysts during the oxidization of iron (Bong-Yeon Cho, 2005).

Vyredox Technology

Vyredox Technology involves the in situ removal of iron from groundwater. The process is the oxidation of the soluble form of iron into insoluble form before taking water from the well. Injection of aerated or oxygenated water into the aquifer(R.O. Hallberg and R. Martinell, 1976) Oruna et.al developed a mathematical model for the in situ

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removal of iron from the groundwater. This oxygenated water with zero traces of iron was injected into the water coming from groundwater wells. After this process, iron bacteria started growing in this system and the bacteria converts soluble Fe^{2+} to insoluble Fe^{3+} form of iron. Later on, excessive iron is filtered through simple filtration techniques. (C.A.J. Appelo and B. Drijver, 1999)

Removal through a supercritical fluid.

A fluid turns into a supercritical fluid (SFC) when it is heated and compressed above critical pressure and temperature. Among various SFC's supercritical carbon dioxide has gained much popularity due to its non-toxicity, low cost, less critical pressure, and low critical temperature. Superfluid extractions extract the metal piece from a solid or liquid source (C. Erkey, 2000). The efficiency of the extraction process depends upon stability and solubility of ligand, pH of water, pressure, and temperature, and metal species in chemically active form. To overcome the problem of the low solubility of metal ions in CO_2, chelating ions such as Thenoyl Trifluoroacetate and Fluroether Dithiocarbamite were used in the cell containing aqueous solution and chelating agents, CO_2 was injected into it at constant pressure for a time for 20h. The iron removal efficiency using chelate Thenoyl Trifluoroacetate was 98% and 85% using Fluroether Dithiocarbamate. (M.A. McHugh and V.J. Krukonis, 1994)

Electrocoagulation Technique

This method is used to destabilize dissolved pollutants present in water by applying an electric current in the contaminated water. The pollutant gets removed from water due to the neutralization of the electric charge. A key feature of this process is the zero involvement of chemicals and ease of operation (M.Y.A. Mollah and R. Schennach, 2001). This process is often combined with electro flotation and is known as the electrocoagulation/floatation process. The amorphous aluminum hydroxide formed from the electrode of aluminum has a high sorption capacity. Initially, the iron is oxidized to Fe(iii) and this process is followed by adsorption and precipitation using Aluminum hydroxide. As an advanced technology flow column reactor (FCR) was used to remove iron from drinking water. This FCR based process reduced the concentration of iron from 20 mg/L to 0.3 mg/L at pH 6 in a time duration of 20 minutes. The combination of FCR along with the electrocoagulation process is more economical. (K. Rajeshwar and J. Ibanez 1997)

Membrane Technology-based Strategy

Some of the common techniques involving different types of membranes include Ultrafiltration(UF), microfiltration (MF), and reverse osmosis. These techniques are used generally to remove metals from water. Considering the size of the pores in membranes used for ultrafiltration and microfiltration, their size is greater than metal ions. Therefore ions have to be pretreated with surfactants and hydrophilic polymers to increase their size (N.L. Le and S.P. Nunes, 2016) These microfiltration systems are used in combination with an oxidation agent, in this case, NaoCl was used as an oxidizing agent to form iron oxide before passing the iron-rich groundwater through the MF system. They have an iron removal efficiency of more than 95%. Polymeric membranes modified with different pore generating agents have also been employed for iron removal from an aqueous system. Polyethersulfone based polymeric membranes modified with Polyvinylpyrrolidone (PVP) as pore generation agent was used for removal of iron from water. Future research works regarding iron removal are focused on membrane technology and nanotechnology integrated with conventional methods. (T.A. Kurniawan and G.Y. Chan 2006)

3.2 Various Technologies Available for Removing E.coli Bacteria from Water

E.Coli Removal Thorugh Membrane Technologies

Using low-pressure microfiltration membranes viruses are removed from both groundwater and wastewater. Various researches are still taking place concerning this section. In a study conducted by S.S Madanei and A.G Fane (1995) Millipore, hydrophobic multi filtration membranes with a pore size of 0.22µm and Amicon polysulfone PM 30 ultrafiltration membranes were used. The possibility of filtering E.coli bacteria was checked in a laboratory condition. E.coli bacteria is a straight rod 0.5 µm in width, 2 µm in length with an electrical conductivity of -4 to -6 (µm/s /V/cm). these were prepared artificially by inoculating a cryopreservative bead culture into 20ml of tryptone soy broth McCartney bottles. After the filtration process membranes were immersed in a solution of 0.1M sodium cacodylate plus 2.5% glutaraldehyde for 30 min and then washed and stored in 0.1 M sodium cacodylate buffer. When viewed through an electron microscope high rejection of E.coli bacteria was observed due to the absorption of the virus within membranes.

E.coli Bacteria Filtration Using Mycofiltration

Alicia Ann Fiatt (2003) studied the possibility of removing E.coli bacteria from storm stormwater using microfiltration. Mycofilter was prepared by drilling a hole in the center bottom of a 5-gallon bucket, the diameter of the inner ring is 1 inch and the diameter of the outer ring is 2 inches, a wire mesh screen cut to a 4-inch diameter was placed over the holes on the inside of the bucket and tackled at 4 edges with silicon glue. Mycofilter was submerged initially in 9L of dechlorinated tap water with no presence of E.coli bacteria to achieve saturation and was allowed to drain for 15 minutes before testing. After the submerging process, each mycofilter was loaded from an individual 30L batch of influent. For preparing influents a large plastic container was filled with 30L of tap water which was dechlorinated with 0.75g of sodium thiosulfate. The culture of E.coli (final influent volume of 30L with a concentration of around 700 CFU/ 100ml) was prepared and the dechlorinated tapwater containing -700cfu/100mL E.coli was percolated through mycofilter at a rate of 0.5L/min. The filter media used was Stropharia spp. on wood chips and shredded chips. After the entire process, the samples were checked separately by using the Coliscan C MF method and was tested negative for E.coli bacteria.

Removal of E.Coli Bacteria Using Carbon Nanotubes Interaction With Microwave Radiation

A study was conducted by Sameer M and Amjad B Khalid (2013)about the possibility of removing e.coli bacteria using carbon nanotubes along with microwave radiation. Multiwalled carbon nanotubes were selected for the process which gave an efficiency of about 95%. The outer and inner diameters of carbon nanotubes were 10-20mm and 5-10mm respectively. The carbon nanotubes were then esterified using the Fischer esterification method. 10g of 1- Octadecanol was melted on a hotplate at 350K and 1g of oxidatively modified carbon nanotubes were added. Few drops of sulphuric acid were added as a catalyst. The product thus formed is washed with deionized water and acetone a few times resulting in the formation of functionalized M-CNT material. Using this functionalized M-CNT and microwave radiation significantly reduced the E.coli bacteria from the sample water. When the time of radiation subjection is increased to 12 seconds a sharp reduction was observed, yielding a reduction of 4 logs (99.99% removal). This effect causes a polarization effect on the cell wall of E.coli bacteria.

4.0 CONCLUSION AND SUGGESTIONS

The review of various methods for removing E.coli bacteria and excessive iron content from the water was conducted to suggest the most economical and easiest method for Aryad panchayath in Alappuzha. The groundwater tested from the panchayath depicted large traces of iron and confirmed the presence of E.coli bacteria in it. Various technologies were reviewed to find the apt technology for water purification in Alappuzha. The per-capita income of the people in Aryad panchayath is low as most of the people are small scale farmers engaged in agriculture, fishing, and coir industry, so the selection of the purification process is based on efficiency and economic feasibility. For the removal of excessive iron content, Vyredox Technology will be most suitable for Aryad panchayath. The efficiency of this process is calculated and found that a one-tenth reduction in the amount of iron from its initial concentration from groundwater. Also, this process is very economical and the efficiency of iron removal was found to be 3.12. For removing E.coli bacteria filtration of water with functionalized carbon nanotubes along with microwave radiation. When ordinary carbon nanotubes are treated with 10g of 1-Octadecanol and melted at a hotplate along with some drops of sulphuric acid functionalized M-CNT materials are formed. This material along with subjection of contaminated water to microwave radiation up to 12 seconds can kill 99.99% of E.coli bacteria.

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