Defluoridation by Natural Method in the Groundwater of Tiruchengode Taluk, Namakkal District

A. Arun Kumar
Department of Chemistry,
Kongunadu College of Engineering and Technology,
Thottiyam, Trichy - 621215, Tamil Nadu. India.

S. M. Mazhar Nazeeb Khan
PG & Research Department of chemistry,
Jamal Mohamed College (Autonomous**)**,
Tiruchirappalli-620 020, Tamil Nadu, India.

Abstract **- The sources of ground water supply mostly depend upon the rain fall and the resulting percolation of the water in the earth, another important factor is the type and quality of the soil. The main objective of this paper was to attempt the removal of fluoride by using natural clay. Fluoride is naturally occurring toxic mineral present in water. Excess of fluoride content in ground water it leads to create many diseases and disorders. The process of removal of excess fluoride from water is described as defluoridation.**

Key Words: Groundwater, Fluoride ,WHO, Defluoridation.

I.INTRODUCTION

Water is the most vital source for all kinds of life on this planet. The present days, advancement and development of the world is directly linked with the harnessing and utilization of natural resources of both surface and ground water. Particularly ground water resources of our country play a major role in drinking, agriculture, live stock production, forestry and industrial activities.[17]

The ground water is defined as water that is found underground in cracks and spaces in soil, sand and rocks. This source has two distinct functions, firstly, it is a significant source of both urban and rural population's water supply and secondly it sustains many wetland ecosystems.[4]

The daily demand of drinking water of a man is normally 7% of his body weight. This is vital for the health and growth of persons. But the same water may become a hazard, a threat to the continuation of life if it gets polluted with harmful substances.[1]

Ground water has unique features, which render it particularly suitable for public water supply. It has excellent natural quality usually free from pathogens, color and turbidity that can be consumed directly without treatment. Ground water is widely distributed and can be frequently developed incrementally at points near the water demand, thus avoiding the need for large scale storage, treatment and distribution systems. Ground water is particularly important as it accounts for about 88% widely dispersed and the infrastructure needed for treatment and transportation of surface water does not exist.

Unfortunately, the availability of ground water is not unlimited nor it is protected from deterioration. In most of the instances the extraction of excessive quantities of ground water has resulted in drying up of wells, damaged eco systems, land subsidence, salt water intrusion and depletion of the resource. The problem of ground water pollution in the several parts of the country has become so acute that unless urgent stops for detailed identification and abatement are taken, extensive ground water resources may be damaged. There are many sources that contribute contaminants to the ground water e.g, land disposal of solid wastes, sewage disposal on land, agricultural activities, urban runoff and polluted ground water.[13] Occurrence of Fluoride

Most of the fluoride found in ground water is naturally occurring from the break down of rocks and soils or weathering and depositing of atmospheric particles. The occurrences of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between rock and the circulating ground water.[7]

The occurrence of high fluoride in ground water has drawn considerable attention the world over, since ground water is the main source of fluoride intake. X-ray diffraction and petro graphic analysis of rock samples collected from the high fluoride incidence zone were carried out for identification of minerals constituting the host rock. Geographic information system was used for spatial analysis of geological and hydro chemical data.[8] History and source of fluoride

Fluorides makes the compounds of both organic and inorganic substances organic fluorides are the most important for environmental exposure through water and food based on quantities released and concentrations present naturally in the environment as well as effect on living organisms. The most relevant inorganic fluoride (CaF_2) Sodium Fluoride (NaF), Sulfur hexafluoride (SF_6).

In the earth's crust Fluoride does not occur in elemental state, but Fluoride are found every where in soil, air and water as well as plant and animal life.

Fluorides are released to the atmosphere through the weathering and dissolution of minerals, due to emissions from valconoes and in marine aerosols. Fluorides are also released into the atmosphere via coal combustion and processing of waters and wastes from various industrial processes, including manufacturing of aluminium, copper and nickel and phosphate processing for phosphate fertilizer production etc[30].

The main natural source of inorganic Fluorides in soil is the parent rock. During weathering some Fluoride mineral such as cryolite ($NaAlF_6$) are rapidly broken down, especially under acidic conditions. Other minerals such as Fluoropatite ($CaS(PO_4)_3F$) and calcium fluoride (CaF) are dissolved slowly.

Fluorospar occurs in structurally weak planes such as fracture zones, joints and at the contact of host rock and quarter vein, Rock and minerals weathering and from calcium and magnesium carbonates which serves as good sinks for fluoride[21].

Characteristics of fluoride

Fluorine (F) is the most reactive non-metal and the most electronegative element and therefore almost never occurs in nature in its elemental state. It combines with all elements, except oxygen and noble gases to form suitable fluorides.

Fluorine is the 13th most abundant element in the earth's crust (625mgkg-1) and exist in trace amounts in almost all ground water throughout the world.

In India Fluoride is the major inorganic pollutant of natural origin found in ground water. At present, it has been estimated that fluorosis is prevalent in 17 states of India. The safe limit of fluoride in drinking water is 1mg/l (WHO.1984) the endemic fluorosis in India is largely of hydro geo chemical origin.

Fluoride being a highly electronegative element has extraordinary tendency to get attracted by positively charged ion like calcium. Hence the effect of fluoride on mineralized tissues like both and teeth leading to developmental alternations is of clinical significance as they have highest amount of calcium and thus attract the maximum amount of fluoride that gets deposited as calcium fluoroapatite crystals.

Drinking water sources of an area are influenced by the physiographic and hydrologic conditions of that area. If the bedrock of a particular area consists number of fluoride bearing minerals, such as fluoride, topaz, apatite, rock phosphate etc., when the bedrock weathers- a natural chemical process in which the rock slowly crumbles to from soils the fluoride leaches in to the water and soil.

Fluoride occurs widespread in the lithosphere as a component of rock minerals. India is considered to be one of the richest countries in the world for the occurrence of fluoride bearing minerals. In the case of geographical expand and varied geological setup of India, the causes of fluoridation of ground water are many. Fluoride bearing minerals present in the rocks are leached out due to various natural processes such as soil formation. Volcanic activities also release gaseous fluorine in to the ground water. The anthropogenic sources of fluoride are the industrial emissions such as Freon's, organo fluorine compounds produced by the burning of fossil fuels and from dust in cryolite factories. Fluoride is also released in to the water from aluminium industries and phosphate reduction plants.

Fluoride is often called a two-edged sword. Fluoride in small dosage has remarkable influence in the dental system by inhibiting carries and while in higher dosage causes dental and skeletal fluorosis. Fluoridation of water in small amounts is necessary, where the health problems regarded with low fluoride consumption is reported and should take fluoridation techniques,

Where the drinking water sources contaminated with high levels of fluoride concentration.[30]

II. EXPERIMENTAL

Defluoridation Technique

Defluoridation is the process of removal of excess Fluoride ion from water. Several methods have been suggested for removing excessive Fluoride in w ater. Depending on their mode of action the defluoridation techniques could be divided in to three types.

(a) Based on chemical reaction with Fluoride

(b) Based on ion exchange

(c) Based on adsorption process

However, due to their high cost lower efficiency or non applicablity on mass scale these techniques are nor in much use. In the presence investigation the traditional method of using clay for defluoridation was employed.

Clay

Clay is a naturally occurring aluminum silicate composed primarily of fine-grained minerals. Clay deposits are mostly composed of clay minerals, a subtype of Phyllosilicate minerals, which impart plasticity and harden when fired or dried they also contain variable amounts of water trapped in the mineral structure by polar attraction. Organic materials which do not impart plasticity may also be a part of clay deposits.

Depending on the academic source, there are three or four main groups of clays kaolinite, montmorillonite-smectite, illite and chlorite.

Chlorites are not always considered clay, sometimes being classified as a separate group within the phyllosilicates. There are approximately 30 different types of "pure" clays in these categories, but most "natural" clays are mixtures of these different types, along with other weathered minerals.

Characteristics of clay

Clay and clay minerals have been mined since the stone Age, today they are among the most important minerals used by manufacturing and environmental industries. The U.S. Geological Survey (USGS) supports studies the properties of clays, the mechanisms of clay information, and the behavior of clays during weathering. These studies can

tell us how and where these minerals form and provide industry and land-planning agencies with the information necessary to decide how and where clay and clay minimal effects on the environment.

The term "clay" is applied both to materials having a particle size of less than 2 micrometers (25,400 micrometers= 1 inch) and to the family of minerals that has similar chemical compositions and common crystal structural characteristics described in the next section. Clay minerals have a wide range of particle sizes from 10's angstroms to millimerters.(An angstrom (Å) is a unit of measure at the scale of atoms.)

Thus, clays may be composed of mixtures of finer grained clay minerals and clay-sized crystals of other minerals such as quartz, carbonate, and metal oxides. Clays and clay minerals are found mainly on or near the surface of the earth.

Physical and Chemical Properties of Clays

The characteristics common to all clay minerals derive from their chemical composition. Layered structure, and size. Clay minerals all have a great affinity for water. Some swell easily and may double in thickness when wet. Most have the ability to soak up ions (electrically charged atoms and molecules) from a solution and release the ions later when condition change.

Water molecules are strongly attracted to clay mineral surfaces. When a little clay is added to water, slurry forms because the clay distributes itself evenly throughout the water. This property of clay is used by the paint industry to disperse pigment. A mixture of a lot of clay and a little water results in a mud that can be shaped and dried to form a relatively rigid solid. This property is exploited by potters and the ceramics industry to produce homogeneous liners for containment of waste.

The process by which some clay minerals swell when take up water is reversible. Swelling clay expands or contracts in response to changes in environmental factors(wet and dry conditions, temperature). Hydration and dehydration can vary the thickness of a single clay particle by almost 100 percent for example a 10Å-thick clay mineral can expand to 19.5 Å in water.

Houses, offices, schools, and factories built on soils containing swelling clays may be subject to structural damage caused by seasonal swelling of the clay portion of the soil.

Another important property of clay minerals, the ability of exchange ions, relates to the charged surface of clay minerals. Ions can be attracted to surface of a clay particle or taken up within the structure of these minerals. The property of clay minerals that causes ions in solution to be fixed on clay surfaces or within internal sites applies to all types of ions, including organic molecules like pesticides, Clays can be an important vehicle for transporting and widely dispersing contaminants from one area to another.

Medical and agricultural uses

A traditional use of clay as medicine goes back to prehistoric times. An example is Armenian bole, which is used to soothe an upset stomach, similar to the way parrots (and later humans) in South America originally used it. Kaolin clay and attapulgite have been used as anti-diarrheal medicines.

Historical and modern uses

Clays exhibit plasticity when mixed with water in certain proportions. When dry, clay becomes firm and when fired in a kiln, permanent physical and chemical changes occur. These reactions, among other changes, cause the clay to be converted in to a ceramic material.

Because of these properties, clay is used for making pottery items, both utilitarian and decorative. Different types of clay, when used with different minerals and firing conditions, are used to produce earthenware, stone ware and porcelain. Prehistoric humans discovered is a drinking vessel made of sun dried clay. Depending on the content of the soil, clay can appear in various colors, from a dull gray to a deep orange-red.

Clay tablets were used as the first known writing medium, inscribed with cuneiform script through the use of a blunt reed called a stylus.

Clays sintered in fire were the first form of ceramic. Bricks, cooking pots, art objects, dishware, and even musical instruments such as the ocarina can all be shaped from clay before being fired. Clay is also used in many industrial processes, such as paper making, cement production and chemical filtering. Clay is also often used in the manufacture of pipes for smoking tobacco. Until the late 20^{th} century bentonite clay was widely used as a mold binder in the manufacture of sand castings.

Clay, being relatively impermeable to water, is also used where natural seals are needed such as in the cores of dams, or as a barrier in landfills against toxic seepage (lining the landfill, preferably in combination with geotextiles).

Recent studies have investigated clay's absorption capacities in various applications such as the removal of heavy metals from waste water and air purification.

Natural method of Defluoridation
(Adsorption process)

Defluoridation techniques are mostly categorized in the four major types, namely adsorption, Ion exchange, Precipitation and membrane process which include reverse osmosis, nano filtration and electrodialysis methods. Among the methods reported earlieradsorption method seemed to be most effective and convenient process, because of its easy operation and cost effectiveness. The efficiency of adsorption process depends upon the nature of adsorption process depends upon the nature adsorbent. Different sorbent material used for defluoridation techniques includes activated alumina, ion exchange resin, zeolite activated carbon, hydroxypatite, hydrotilicate, ion exchanger, chitosan beads, composites etc.

The first comprehensive study of fluoride sorption on to minerals and soils was reported by bower and hutcher 1967. Since then several works have been published which includes fluoride sorption by kaolinites and monomorillonites, modified kaolites, red mud, bleaching earth etc. Kaolinites area sheet silicates where tetrahydron silicate to octahydron alumino sheets in to the ratio 1:1 and the changes of two sheet layer is zero with the general formula $Al_4[Si_4O_{10}](OH)_8$. It is observed that from mine compositionof clay minerals deffers and sorption capacity may also differ.

The clay material for defluoridation was obtained from Manachanallur paddy fields. It was powdered well and coarse particles were removed. It was sieved and fine powder was collected.

100ml sample containing fluoride ions were taken, 50g of powdered clay was added. It was stirred well. And allowed undisturbed for 48 hours. The solution was decanted. Fluoride analysis was conducted. It was find that 4/5 quantity of fluoride was removed by adsorption. This method was economically viable. It was successfully removing a major part of fluoride from the ground water.

From the literature it was find that in clay material the silicon ions are found to be surrounded by four oxygen ions. And each aluminum ion coordinates with four hydroxyl group and two oxygen ions. This hexagonally shaped crystal carries a negative charge on the basal surface. It is generally assumed due to substitution of aluminum for silicon in tetrahedral layer with a consequent imbalance of negative charge.

Defluoridation was carried out successfully by Natural method.

Table.1

Sl.No	Name of the place	April 2012	July 2012
1	CHITALANDUR 1	0.44	0.41
2	CHITALANDUR 2	0.52	0.38
3	CHITALANDUR 3	0.41	0.37
4	PUDHU PULIAMPATTY 1	1.7	1.0
5	PUDHU PULIAMPATTY 2	2.3	0.70
6	PUDHU PULIAMPATTY 3	1.5	1.3
7	SIRUMOLASI 1	1.1	1.1
8	SIRUMOLASI 2	1.7	1.3
9	SIRUMOLASI 3	0.84	1.2
10	ANIMOOR 1	0.95	0.91
11	ANIMOOR 2	1.1	0.92
12	ANIMOOR 3	1.1	0.99

Table.2 Defluoridation process

S.No	NAME OF THE PLACE	BEFORE DEFLUORIDATION	AFTER DEFLUORIDATION
1	PUDHU PULIAMPATTY 1	1.7	0.24
2	PUDHU PULIAMPATTY 2	2.3	0.26
3	SIRUMOLASI 2	1.7	0.23

REFERENCES

[1] Abbasi, S.A(1999). Water quality in and around an industrialized suburb of Pondicherry. Indian Journals of environmental health,41(4) 253-263.
[2] Acharya,G.D (2010). Fluoride contamination in ground water sources of modasa tehsil of sabarkantha District, Gujarat, India Pollution Research, 29(1),43-45.
[3] Asadi,S.S.(2007). Remote sensing and GIS techniques for evaluation of ground water quality in municipal corporation of Hyderabad, India. International Journal of environmental research and public health, 4(1), 45-52.
[4] AneethaRosaireBapsite,(2002). Water chemistry and heavy metals in some fresh water ponds of palavakkam, Chennai, Tamilnadu. Journals of aquatic Biology, 23-25.
[5] Ashwini,V.(2010). Ground water fluoride in Rajura Tehsil in chandrapur district, Mahastra,30(10),823-831.
[6] Ayoob,S.(2006).Fluorides in drinking water. A review of the status and stress effects. Critical reviews in environmental science and technology, 36(6), 433-487.
[7] Babular Das, (2008). Fluorides and other inorganic constituents in ground water in Guwhati, Assam, India, Current science, 85(5),659-661.
[8] Beg,M.k.(2001). High fluoride incident in ground water and its potential health effects in parts of Rajgarh district, Chattisgarh, india. Current science, 100(5) 750-754.