Study on Rainwater Harvesting at Domestic Level in Some Fluoride Affected Areas of Bihar

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Abstract - **Ground water source is the major source for various purposes in most parts of the world. Presence of low or high concentration of certain ions is a major issue as they make the groundwater unsuitable for various purposes. Fluoride is one such ion that causes health problems in people living in more than twenty five country around the world. Fluoride concentration of at least 0.6 mg/l is required for human consumption as it will help to have stronger teeth and bones. Consumption of water with fluoride concentration above 1.5 mg/l results in acute to chronic dental fluorosis where the tooth become coloured from yellow to brown. Skeletal fluorosis which causes weakness and bending of the bones also results due to long term consumption of water containing high fluoride. Presence of low or high concentration of fluoride in groundwater is because of natural or anthropogenic causes or a combination of both. Natural sources are associated to the geological conditions of an area. Several rocks have fluoride bearing minerals like apatite, fluorite, biotite and hornblende. The weathering of these rocks and infiltration of rainfall through it increases fluoride concentration in groundwater. Fluoride which is present in high concentration in volcanic ash is readily soluble in water and forms another natural source. Anthropogenic sources of fluoride include agricultural fertilisers and combustion of coal. Phosphate fertilisers contribute to fluoride in irrigation lands. Coal which is a potential source of fluoride is used for combustion in various industries and in brick kilns. The aerial emission of fluoride in gaseous form during these activities reaches the surface by fall out of particulate fluorides and during rainfall they percolate with the rainwater thus reaching the groundwater table. Also the improper disposal of fly ash on ground surface contributes to fluoride in groundwater. Since ingestion of high fluoride has a long term effect on human health it is essential to monitor its concentration in groundwater used for drinking periodically and take steps to bring them within the permissible range of 0.6 to 1.5 mg/l. There are several methods available for the removal of fluoride from groundwater which is insitu or exsitu. To dilute the groundwater contaminated with fluoride, artificial recharging structures can be built in suitable places which will decrease its concentration. Rainwater harvesting through existing wells also will prove effective to reduce the groundwater fluoride concentration. Exsitu methods which are conventional treatment methods like adsorption, ion exchange, reverse osmosis, electrodialysis, coagulation and precipitation etc. can be practiced at community level or at households to reduce fluoride concentration before ingestion. Each method depends on the local conditions of the region such as the quality of groundwater and the source of contamination whether it is natural or anthropogenic. Fluoride contamination being a prominent and widespread problem in several parts of the world and as causes for this are mostly natural and unpreventable, educating the people and defluorinating the groundwater before consumption are essential for a healthy world.**

keywords - **Storage tank, Drinking water, Household, Rainwater, Ground water recharge, Fluoride.**

INTRODUCTION

It is well known that about 70 % of the earth's surface is covered with water. Most of the water is in the oceans (96.5%) in the unusable form while some of them are frozen (1.74%). Lakes, swamp water and rivers hold 0.014% and soil moisture accounts for 0.001%. Water also exists in the form of vapour in the air (0.001%) and as groundwater beneath the sub surface in the aquifers (1.7%). World's water needs are met from surface and groundwater resources. However, use of groundwater is advantageous as it is comparatively fresh and widely distributed unlike the surface water. Threats to groundwater have been increasing everyday due to raise in population and their needs. Thus with increasing demand of groundwater for domestic, industrial and agricultural needs, The pressure on this resource has become enormous. Overexploitation and improper management has also lead to contamination of this resource. The degradation of groundwater may be due to natural or anthropogenic processes. Natural causes are inherent geological conditions while anthropogenic causes include wastewater from sewage treatment plants, discharge from industries, improper solid waste disposal, agrochemicals, runoff from agricultural fields, leakage from underground storage tanks etc.

Rainwater is relatively free from impurities except those picked up by rain from the Atmosphere, but the quality of rainwater may deteriorate during harvesting, storage and household use. Wind-blown dirt, leaves, faecal droppings from birds and animals, insects and contaminated litter on the catchment areas can be sources of contamination of rainwater, leading to health risks from the consumption of contaminated water from storage tanks. Poor hygiene in storing water in and abstracting water from tanks or at the point of use can also represent a health concern. However, risks from these hazards can be minimized by good design and practice. Well designed rainwater harvesting systems with clean catchments and storage tanks supported by good hygiene at point of use can offer drinking-water with very low health risk, whereas a poorly designed and managed system can pose high

health risks. Fluorosis is a crippling disorder known to occur due to entry of fluoride to the body. Fluoride can reach human body through natural sources- water and soil, and also from food stuffs, toothpaste and even air (mostly from phosphate fertilizers and burning of fluoride containing fuels). However drinking water extracted from ground water aquifers is the most common source of fluoride intake. In some regions of the world including our country and the state (i.e. Bihar) earth crust is rich in fluoride bearing minerals due to which the ground water is naturally fluoridated. Intake of excess fluoridated water for prolong period causes fluorosis which is a proven cause of physical deformities of one kind or the other.

SCENARIO IN BIHAR:

In Bihar about 6000 habitations spread over 11 districts have been found to have visible causes of fluorosis in large number of the population there due to intake of fluoride contaminated drinking water extracted from ground water sources.

RAINWATER HARVESTINS METHOD:

It is easy to collect Rain water from the building, roofs and numerous Other sources. As long as you are ready and you have everything with a few different items, what it needs, harvest rain water and enjoy naturally delicious, clean and useful water start. Rainwater harvesting systems can be purchased from various home improvement stores completely. The cost of these systems are different. Broadly there are two ways of harvesting rainwater.

(i) Surface runoff harvesting- In urban area rainwater flows away as surface runoff. This runoff could be caught and used for recharging aquifers by adopting appropriate methods.

(ii) Roof top rainwater harvesting- It is the system collect rainwater, where it is harvest falls. In on the roof is the catchment area and collected rainwater, from roof of building. It can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area.

PROPERTIES OF FLUORIDE

Fluoride belongs to halogen family represented as 'F' with atomic weight 18.998 and atomic number 9. It occurs as a diatomic gas in its elemental form and has a valence number 1. It is the most electronegative and the most reactive when compared to all chemical elements in the periodic table. It has an oxidation state of -1 and occurs as both organic and inorganic compounds. It is the 13th most abundant element in the earth's crust. Its natural abundance in the earth's crust is 0.06 to 0.09% and the average crustal abundance is 300 mg/kg. Fluoride does not exhibit any colour, taste or smell when dissolved in water. Hence, it is not easy to determine it through physical examination. Only chemical analysis of the groundwater samples can determine the concentration of this ion. The widely used method for the estimation of fluoride in groundwater sample is colorimetric SPANDNS (sodium 2-(parasulfophenylazo)-l,8-dihydroxy-3,6-naphthalene disulfonate) method. The other colorimetric method extensively used is the complexone method. Fluoride concentration can also be quantified using sophisticated instruments like ion chromatograph. Ion selective electrodes are available to measure fluoride concentration in water, which can be used both in the field and in laboratory. Fluoride is one of the important micronutrient in humans which is required for strong teeth and bones. In humans, about 95% of the total body fluoride is found in bones and teeth. WHO (World Health Organisation) (1984) has prescribed the range of fluoride from 0.6 to 1.5 mg/l in drinking water as suitable for human consumption. BIS (Bureau of Indian Standards) (1992) has set a required desirable range of fluoride in drinking water to be between 0.6 and 1.2 mg/l. However, this standard suggests the maximum permissible limit can be extended up to 1.5 mg/l. This required fluoride is supplied to the human body usually through drinking water. Consumption of water with fluoride below or above the prescribed range is detrimental to human health. Hence, it is essential to monitor the groundwater quality regularly which is used directly without treatment as drinking water.

CAUSES FOR FLUORIDE

Aquifer material - Most of the fluoride in groundwater is naturally present due to weathering of rocks rich in fluoride. Water with high concentration of fluoride is mostly found in sediments of marine origin and at the foot of mountainous areas. Known fluoride belts on land include: from Syria through Jordan, Egypt, Libya, Algeria, Sudan and Kenya, from Turkey through Iraq, Iran, Afghanistan, India, northern Thailand and China. There are also same kind of belts in the America and Japan (WHO, 2001). Fluorite occurs in igneous and sedimentary rocks.

Volcanic ash - Volcanic rocks are often enriched in fluoride. Hydrogen fluorine is one of the most soluble gases in magmas and comes out partially during eruptive activity. The aerial emission of fluoride in the form of volcanic ash during volcanic eruption reaches the surface by fall out of particulate fluorides and during rainfall. This fluoride from the soil surface will easily reach the groundwater zone along with percolating rainwater. Volcanic eruptions are common in Iceland and fluorosis poisoning in livestock and humans was identified long ago in 1978.

Fly ash - Like volcanic ash, fly ash from the combustion of fossil fuels also account for high fluoride. More than 100 to 150 million tons of fly ash is produced worldwide annually due to the combustion of coal especially from power plants. Inappropriate disposal of this fly ash will result in the leaching of fluoride to groundwater. Coal contains 40 to 295 mg of fluoride/kg. But the fluoride content of coal depends on the type of coal being burnt. Brick kilns which use coal for burning also account as a source for fluoride pollution.

Water quality and health risk

Rainwater is relatively free from impurities except those picked up by rain from the atmosphere, but the quality of rainwater may deteriorate during harvesting, storage and household use. Wind-blown dirt, leaves, faecal droppings from birds and animals, insects and contaminated litter on the catchment areas can be sources of contamination of rainwater, leading to health risks from the consumption of contaminated water from storage tanks. Poor hygiene in storing water in and abstracting water from tanks or at the point of use can also represent a health concern. However, risks from these hazards can be minimized by good design and practice. Well designed rainwater harvesting systems with clean catchments and storage tanks supported by good hygiene at point of use can offer drinking-water with very low health risk, whereas a poorly designed and managed system can pose high health risks. Microbial contamination of collected rainwater indicated by E. coli (or, alternatively, thermotolerants coliforms) is

quite common, particularly in samples collected shortly after rainfall. Pathogens such as Cryptosporidium, Giardia, Campylobacter, Vibrio, Salmonella, Shigella and Pseudomonas have also been detected in rainwater. However, the occurrence of pathogens is generally lower in rainwater than in unprotected surface waters, and the presence of non-bacterial pathogens, in particular, can be minimized. Higher microbial concentrations are generally found in the first flush of rainwater, and the level of contamination reduces as the rain continues. A significant reduction of microbial contamination can be found in rainy seasons when catchments are frequently washed with fresh rainwater. Storage tanks can present breeding sites for mosquitoes, including species that transmit dengue virus. Rainwater is slightly acidic and very low in dissolved minerals. As such, it is relatively aggressive. Rainwater can dissolve heavy metals and other impurities from materials of the catchment and storage tank. In most cases, chemical concentrations in rainwater are within acceptable limits; however, elevated levels of zinc and lead have sometimes been reported. This could be from leaching from metallic roofs and storage tanks or from atmospheric pollution. Rainwater lacks minerals, but some minerals, such as calcium, magnesium, iron and fluoride, in appropriate concentrations are considered very essential for health. Although most essential nutrients are derived from food, the lack of minerals, including calcium and magnesium, in rainwater may represent a concern for those on a mineral-deficient diet. In this circumstance, the implications of using rainwater as the primary source of drinking-water should be considered. The absence of minerals also means that rainwater has a particular taste or lack of taste that may not acceptable to people used to drinking other mineral-rich natural waters. Water quality should be managed through development and application of WSPs that should deal with all components from catchment areas to point of supply.

System risk assessment

Important factors in collecting and maintaining good quality rainwater include proper design and installation/construction of rainwater harvesting systems. Materials used in the catchment and storage tank should be suitable for use in contact with drinking-water and should be non-toxic to humans. Rainwater can be harvested using roof and other above-ground catchments and stored in tanks for use. The roof catchment is connected with a gutter and down-pipe system to deliver rainwater to the storage tank. The quality of rainwater is directly related to the cleanliness of catchments, gutters and storage tanks. Rooftop catchment surfaces collect dust, organic matter, leaves and bird and animal droppings, which can contaminate the stored water and cause sediment buildup in the tank. Care should also be taken to avoid materials or coatings that may cause adverse taste or odour, and some metals can dissolve to give high concentrations in water. Regular cleaning of catchment surfaces and gutters should be undertaken to minimize the accumulation of debris. Wire meshes or inlet filters should be placed over the top of down-pipes to prevent leaves and other debris from entering storages. These meshes and filters should be cleaned regularly to prevent clogging. The first flush of rainwater carries most contaminants into storages. A system is, therefore, necessary to divert the contaminated first flow of rainwater from roof surfaces. Some devices and good practices are available to divert the first foul flush of rainwater. Automatic devices that prevent the first 20–25 litres of runoff from being collected in storages are recommended. If diverters are not available, a detachable down-pipe can be used manually to provide the same result. Even with these measures in place, storages will require periodic cleaning to remove sediment. Storages without covers or with unprotected openings will encourage mosquito breeding, and sunlight reaching the water will promote algal growth. Covers should be fitted, and openings need to be protected by mosquito-proof mesh. Cracks in the tank and withdrawing of water using contaminated pots can contaminate stored water. Storages should preferably be fitted with a mechanism such as a tap or outlet pipe that enables hygienic abstraction of water. Some households incorporate cartridge filters or other treatments at the point of consumption to ensure better quality of drinking-water and reduce health risk.

Insitu-treatment methods- Insitu method aims at directly diluting the concentration of fluoride (in groundwater) in the aquifer. This can be achieved by artificial recharge. India has helped widely to reduce fluoride concentration in groundwater. Rainfall recharge also called as rainwater harvesting can be adopted using percolation tanks and recharge pits which may prove helpful. Recharge of rainwater after filtration through the existing wells can also be planned to improve the groundwater quality.

SUMMARY AND CONCLUSION - It is evident from studies by several researchers worldwide that fluoride in groundwater has been a potential problem to human society. The main source of fluoride in groundwater is the rocks which are rich in fluoride. Fluoride occurs in sellaite, fluorite, cryolite, fluorapatite, apatite, fluormica, biotite, amphibole and several other rocks. Weathering of these rocks and prolonged residence time leads to high fluoride groundwater. Low calcium, high sodium and high bicarbonate are typical of high fluoride groundwater. Volcanic ash and combustion of coal are the next major source for fluoride. The other sources for fluoride are infiltration of agricultural runoff containing chemical fertilisers, improper disposal of liquid waste from industries, alumina smelting, cement production and ceramic and brick firing. Some amount of fluoride is essential for the human body for healthy teeth and bones. But when they are present above the recommended limit of WHO and BIS i.e. 1.5 mg/l it results in mild dental fluorosis to crippling skeletal fluorosis as the quantity and period of exposure increases. Dental fluorosis is more prevalent in children than in adults. Skeletal fluorosis occurs when an individual is exposed to fluoride of above 10 mg almost every day over a period of one or two decades. Apart from fluorosis there are also several health disorders due to ingestion of drinking water with high fluoride. To remediate the groundwater with high fluoride, defluorination techniques are adopted. They include adsorption, ion exchange, coagulation and precipitation, reverse osmosis and electrodialysis. Of these, reverse osmosis has been considered as the best available technology. Onsite treatment includes artificial recharge methods such as Rain water harvesting, constructing check dams, percolation ponds, facilitating recharge of rain water through existing wells etc. Adopting a particular method depends on the initial fluoride concentration, source and cost effectiveness in an area.

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