STUDY ON RAINWATER HARVESTING FOR FLOURIDE FREE FRESH WATER AT DOMESTIC LEVEL IN FLUORIDE AFFECTED AREA IN NAWADA DISTRICT OF BIHAR

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ABSTRACT

KEYWORDS- Population, water, Groundwater. Fluoride, human health rainwater harvesting

Water is one of the essential commodities for survival of human beings. It is required for domestic purpose, irrigation, industrial and other uses, which are very relevant for survival and progress of society. That is important civilisations of the world have grown and prospered around perennial rivers. With rapid growth of population and development of modern technologies in various fields, the requirement of water has substantially increased. The perception that water is available with us in abundance no longer holds true now. Water availability is neither adequate nor equitable to all human beings and in all regions of the country as well as in the world. The global fresh water consumption has risen six folds between 1900 and 1995, which is more than twice the rate of population growth. However, one-third of the world's population is already living in countries with moderate to high water stress. About 20 percent of the world's population, lack access to safe drinking water. The problem is more acute in Africa and West Asia and in many other developing countries including our country India. In addition to the problems of limited availability of water, there is problem of water quality leading to various biological and chemical contamination. Even developed countries like United States are also affected by water quality degradation. India has more than 20 states and millions of people affected with Fluorosis, but Bihar is not one of the states that is recognized widely as highly affected with Fluoride in drinking water and affected with Fluorosis. Fluoride is often associated with scarcity of water and the perception of Bihar is often that of water plentiness. But what we often forget is the diversity that is there within this state.

INTRODUCTION

Rainwater harvesting is a technology used to collect rain water and store or lastly recharge ground water. for later use from relatively clean surfaces such as a roof, land surface or rock catchment. Rain water harvesting is the technique of collecting water from roof, Filtering and storing for further uses. Rainwater Harvesting is a simple technique of catching and holding rainwater where its falls. Either, we can store it in tanks for further use or we can use it to recharge groundwater depending upon the situation. Rain water harvesting system provides sources of soft, high quality water reduces dependence on well and other sources and in many contexts are cost effective. Rain water harvesting system is economically cheaper in construction.

Fluoride contamination in groundwater is a major geo-environmental issue. In India, groundwater sources contribute more than 85 percent of the drinking water requirement in rural areas, 76 percent of irrigation requirements and more than 50 percent of the urban and industrial water supplies. Many studies have reported fluoride-related health problems such as dental and skeletal fluorosis in humans due to drinking of fluoride-rich water which has severe socio-economic implications. The permissible limit of fluoride in drinking water is 1.5 mg/l according to the World Health Organisation (WHO, 2004) and the Bureau of Indian Standards (BIS, 2012). India has more than 21 states and millions of people affected with Fluorosis, but Bihar is not one of the states that is recognized widely as highly affected with Fluoride in drinking water and affected with Fluorosis. Fluoride is often associated with scarcity of water and the perception of Bihar is often that of water plentiness. But what we often forget is the diversity that is there within this state. For the past decade, we have been hearing a lot of caution about Fluorosis in Bihar, but few have been listening. As the situation is being further explored, newer areas are emerging. For example, a recent field trip to nawada revealed several Skeletal fluorosis cases there, that were earlier unknown.

These were however known earlier for other districts of south Bihar. For example, Munger and Gaya are both well known for their Fluorosis cases with numerous pieces of research conducted on the problem there. In fact, the Indian society of Orthopedic surgeons met in Gaya to discuss Skeletal Fluorosis in 2015. There has been extensive reporting of the problem in local and national media. But what causes greater concern is the following. Garhwa lies on the border with Bihar on the south. Along with the region of Sonbhadra in eastern UP, and Singrauli in eastern MP, this forms a massive Fluorosis belt, that is afflicted with serious Skeletal fluorosis disorders in large populations. Here, we get to two key factors that are related to Fluorosis --Geology, and the other Malnutrition.

LOCATION

Nawada is located between North Latitudes 24031’: 25008’ and East Longitudes 85000’: 86003’ and falls on Survey of India Degree sheet No. 72 H & 72 G . The district is bounded in north by Nalanda and Sheikhpura district, in east by Jamui district, in west by Gaya district, while southern half boundary of district is bounded by Jharkhand state boundary. The district is having a geographical area of 2494 Sq. Km and occupying 1.43% of the total geographical area of the Bihar State. The total population of district is 22.16 Lakhs. Density of population is 726 per Sq. Km. Nawada is its district headquarter. There are 14 development blocks with 1075 villages.

The northern and southern parts of the district constitute two distinct natural regions. The northern part is plain area underlain by alluvial soils covering Nawada, Warsaliganj, Pakhribarwan and parts of Hisua, Narhat, Govindpur, Akbarpur and Kauakol blocks. Consequently, it is densely populated and has a rich historical background. The southern part is hilly and undulating with a gentle ascend towards the south merging into hills and is part of southern fringes of the Chotta Nagpur Plateau. The entire southern boundary of the district is a conglomeration of ridges and spurs

RAINFALL & CLIMATE

Monsoon sets sometimes in the third week of June and it lasts till the end of September. The average annual rainfall in Nawada district is 1037 mm. The maximum rainfall in the district comes from South West monsoon with a little about 10% spread over the summer and winter. There is a large variation in the rainfall over year to year. Rainfall increases from Southwest to north-east. After analysis of rainfall data it is revealed that there is a wide variation in the average annual rainfall values, least being at Rajauli and maximum at Nawada.

The climate of the district is sub-tropical to sub-humid in nature. The district experiences severe cold during winter whereas on the other hand in summer it is very hot. The summer starts from the mid of March and it continues up to mid of June, after that monsoon starts and it continues up to mid of October. The nights are generally hot from the end of May till the first break of monsoon.

HUMAN HEALTH IMPACT

Fluoride is not considered to be essential for human growth and development but it is considered to be beneficial in the prevention of dental caries (tooth decay). As a result, intentional fluoridation of drinking water and the development of fluoride containing oral care products (toothpastes and mouth rinses), foods (fluoridated salt) and supplements (fluoride tablets) have been employed since the early 20th century in several parts of the world as a public health protective measure against tooth decay. Additional exposure to fluoride comes from naturally occurring water (tap and mineral) beverages, food, and to a lesser extent from other environmental sources.

A body of scientific literature seems to suggest that fluoride intake may be associated with a number of negative health effects. Dental fluorosis and effects on bones (increased fragility and skeletal fluorosis) are two well documented adverse effects of fluoride intake. Systemic effects following prolonged or high exposure to fluoride have also been reported and more recently effects on the thyroid, developing brain and other tissues, and an association with certain types of osteosarcoma (bone cancer) have been reported. Individual and population exposures to fluoride vary considerably and depend on the high variability in the levels of fluoride found in tap (be it natural or the result of intentional fluoridation of drinking water) and mineral waters, and on individual dietary and oral hygiene habits and practices. The emerging picture from all risk assessments conducted on fluoride is that there 'exists a narrow margin between the recommended intakes for the prevention of dental carries and the upper limits of exposure'. Invariably, all assessments to date call for continued monitoring of the exposure of humans to fluoride from all sources and an evaluation of new scientific developments on its hazard profile.

FLUORIDE EPOSURE CAUSED CANCER

Epidemiological investigations on the effects of fluoride on human health have examined occupationally exposed workers employed primarily in the aluminium smelting industry and populations consuming fluoridated drinking-water. In a number of analytical epidemiological studies of workers occupationally exposed to fluoride, an increased incidence of lung and bladder cancer and increased mortality due to cancer of these and other sites have been observed. In general, however, there has been no consistent pattern; in some of these epidemiological studies, the increased morbidity or mortality due to cancer can be attributed to the workers' exposure to substances other than fluoride. The relationship between the consumption of fluoridated drinking-water and morbidity or mortality due to cancer has been examined in a large number of epidemiological studies, performed in many countries. There is no consistent evidence of an association between the consumption of controlled fluoridated drinking-water and increased morbidity or mortality due to cancer.

FLUORIDE IN BLOOD

Fluoride is rapidly distributed by the systemic circulation to the intracellular and extracellular water of tissues; however, the ion normally accumulates only in calcified tissues, such as bone and teeth. Fluoride is not bound to any plasma proteins. In the blood, the ion is a symmetrically distributed between plasma and the blood cells, so that the plasma concentration is approximately twice as high as that associated with the cells.

There is no homeostatic regulation of the fluoride concentration in the blood. In a short-term human pharmacokinetic study, fluoride doses ranging from 3 to 10 mg were given orally in the form of tablets. The data were interpreted using an open three-compartment model, and the plasma half-life was determined from the final terminal phase, ranging from 3 to 10 h. The plasma level rose and fell during each dosage interval. That is, the fluctuation of the plasma fluoride concentration depended on the fluoride dose ingested, dose frequency and the plasma half-life of fluoride.

The literature contains a wide range (0.4–2.4 μ mol/litre) for "normal" plasma fluoride concentrations. Some of the results may have been due to the use of fasting individuals in some studies and non-fasting in others. It is virtually certain also that problems with the analysis of fluoride have been contributory. This is especially the case when only the fluoride electrode is used for the analysis of samples with low concentrations. The use of preparative methods that concentrate the fluoride in small volumes, such as the acid-HMDS micro diffusion method, is necessary when such low levels of fluoride are to be measured.

Under steady conditions of exposure via drinking-water, the concentration of fluoride in plasma collected from fasting subjects is directly related to the concentration in the drinking-water consumed. The mean concentration of fluoride in the blood plasma of 30 residents of communities in the USA served by drinking-water containing low concentrations of fluoride (i.e., <0.1 mg/litre) was 0.4 μmol/litre, while the mean concentration in plasma from individuals consuming drinking-water containing higher amounts of fluoride (i.e., 0.9–1.0 mg/litre) was reportedly 1 μmol/litre. Serum and plasma contain virtually the same amount of fluoride. There is a considerable variation during the day in plasma fluoride levels in subjects living in an area with a high fluoride concentration in the drinking-water, particularly in adults.

In addition to recent fluoride intake and the level of chronic fluoride intake, plasma fluoride levels are influenced by the relative rates of bone accretion and dissolution and by the renal clearance rate of fluoride. In the long term, there is a positive relationship between the concentration of fluoride in plasma and bone. Also, a positive relationship between plasma fluoride and age has been reported.

The levels of fluoride in plasma, serum and urine have been considered useful biomarkers for fluoride exposure. The concentrations of fluoride in parotid saliva have also been used to assess plasma levels of fluoride. There are, however, ethical and technical limitations of the use of these fluids for large-scale monitoring of the body burden of fluoride in humans. It has been suggested that the fluoride concentration in nails and hair can be used as a marker of fluoride exposure. However, there is only limited information on the reliability of these methods and the risks of contamination during exposure in field conditions. Information on appropriate preparation methods as well as analytical techniques needs to be further evaluated before these methods can be used on a large-scale basis.

EFFECTS ON TEETH AND BONES

Fluoride has both beneficial and detrimental effects on tooth enamel. The prevalence of dental caries is inversely related to the concentration of fluoride in drinking-water. The prevalence of dental fluorosis is highly associated with the concentration of fluoride, with a positive dose esponse relationship. Cases of skeletal fluorosis associated with the consumption of drinking-water containing elevated levels of fluoride continue to be reported. A number of factors, such as nutritional status and diet, climate (related to fluid intake), concomitant exposure to other substances and the intake of fluoride from sources other than drinking-water, are believed to play a significant role in the development of this disease. Skeletal fluorosis may develop in workers occupationally exposed to elevated levels of airborne fluoride; however, only limited new information was identified. Evidence from several ecological studies has suggested that there may be an association between the consumption of fluoridated water and hip fractures. Other studies, however, including analytical epidemiological investigations, have not supported this finding. In some cases, a protective effect of fluoride on fracture has been reported. Our studies permit an evaluation of fracture risk across a range of fluoride intakes. In one study, the relative risks of all fractures and of hip fracture were elevated in groups drinking water with >1.45 mg fluoride/litre (total intake >6.5 mg/day); this difference reached statistical significance for the group drinking water containing >4.32 mg fluoride/litre (total intake 14 mg/day). In the other study, an increased incidence of fractures was observed in one age group of women exposed to fluoride in drinking-water in a non-dose-dependent manner.

OTHER HEALTH PROBLEMS

Epidemiological studies show evidence of an association between the consumption of fluoridated drinking-water by mothers and increased risk of spontaneous abortion or congenital malformation. Other epidemiological investigations of occupationally exposed workers have provided no reasonable evidence of genotoxic effects or systemic effects upon the respiratory, haematopoietic, hepatic or renal systems that may be directly attributable to fluoride exposure.

Advantages of using rooftop rainwater harvesting

• Provides self-sufficiency to water supply.

• Reduces the cost of pumping groundwater.

• Provides high-quality water that is soft and low in minerals.

• Improves the quality of groundwater through dilution when recharged to the ground.

• Reduces soil erosion in urban and rural areas.

• Is a cost-effective and simple technique.

• RWH structures are easy to construct, operate, and maintain.

• In saline or coastal areas rainwater provides good-quality water, and when recharged to the ground, it reduces salinity and also helps in maintaining the balance between the fresh-saline water interface.

• On islands, due to the limited extent of freshwater aquifers, rainwater harvesting is the most preferred source of water for domestic use.

DESIGN PRINCIPLES

Rainwater harvesting system consists of at least the following components

1. Rainfall

2. A catchment area or roof surface to collect rainwater.

3. Delivery systems (gutters) to transport the water from the roof or collection surface to the storage reservoir.

4. Storage reservoirs or tanks to store the water until it is used.

An extraction device depending on the location of the tank - may be a tap, rope and bucket, a pump or a infiltration device in the case the collected water is used for well or groundwater recharge.

Collected water can also be used for replenishing a well or the excess rainwater during the rainy season is used to recharge a dug well, as well as the groundwater. In this case recharging the groundwater even improved the water quality in the dug well.

User Behaviour

Four types of user regimes can be discerned:

1. Occasional - Water is stored for only a few days in a small container. This is suitable when there is a uniform rainfall pattern and very few days without rain and there is a reliable alternative water source nearby.

2. Intermittent - There is one long rainy season when all water demands are met by rainwater, however, during the dry season water is collected from non-rainwater sources. Rainwater Harvesting can then be used to bridge the dry period with the stored water when other sources are dry.

3. Partial - Rainwater is used throughout the year but the 'harvest' is not sufficient for all domestic demands. For instance, rainwater is used for drinking and cooking, while for other domestic uses (e.g. bathing and laundry) water from other sources is used.

4. Full - Only rainwater is used throughout the year for all domestic purposes. In such cases, there is usually no alternative water source other than rainwater, and the available water should be well managed, with enough storage capacity to bridge the dry period.

TREATMENT

Treatment directly diluting the concentration of fluoride (in groundwater) in the aquifer. This can be achieved by artificial recharge. Construction of check dams in Nawada district, 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.

FINDING AND CONCLUSIONS.

Rainwater collected and stored correctly can offer an additional high quality resource at household or small community level. Understanding the various factors affecting quality can help to maintain purity of the resource. Rainwater chemistry will vary from place to place and be influenced by proximity to the oceans, dust and aerosols derived from human activities such as fuel and forest fires. Attention to roof and other collecting surfaces, suitable collection and storage procedures will minimise contamination from pathogens, excess organic material (leading to anaerobic conditions) as well as organic chemicals; discarding the first flush is recommended.

Rainwater capture by check dams and other small structures leads to the infiltration of generally high quality water which may create a seasonal freshwater mound above the regional water table. This water undergoes water-rock interaction in the same way as natural recharge and becomes slightly mineralised, according to the geology. This freshwater may become an important domestic resource along with roof water harvesting in areas affected by high salinity or high fluoride groundwater. The harvested rainwater acts as a means of raising regional water tables. The chemical and isotopic signatures in the water may be used to measure recharge pathways and in favourable circumstances to quantify recharge.

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