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RESEARCH ARTICLE

THE TREATMENT, DISPOSAL, AND SIGNIFICANCE OF FLUORIDE-IRON SLUDGE IN BRICK PRODUCTION

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ABSTRACT

Contamination in drinking water affects society and the phenomenon becomes a global problem. Some contaminants are general and some depend on the geographical location. The extent of the contamination also depends on geographical location. Fluoride is such a contaminant presence of water causes Fluorosis. The maximum permissible limit of fluoride in drinking water is 1.5 mgL^{-1}. Endeavors are going on in chemical Laboratories stored throughout the globe for defluoridation of drinking water and several such procedures have been developed and recommended. But another side of the problem is disposal of the affluent containing fluoride which would be responsible for newer pollution. One way of getting rid of fluoride-rich sludge is to use the same in manufacturing brick. Mixing sludge with clay not only removes the hazards of further pollution but also imparts special characteristics to bricks thus manufactured.

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INTRODUCTION

The terrible and far-reaching menace arising out of contamination in water, especially groundwater pollution has assumed an alarming proportion across the globe including the developing countries like India. The increasing problem of water pollution is primarily attributed to frenzied urbanization, rapid industrialization, boundless encompassment of modernization, etc. As a result of this progressive pollution, deadly diseases and ailments like fluorosis, arsenicosis, silicosis, asbestosis, pesticide, and other intoxication-related diseases including carcinoma, and cardiovascular ones are posing a severe threat to our lives, welfare, and comfort and hence cracking our domestic and social peace and harmony.

Fluorosis which is caused by the presence of an excessive amount of fluoride ion in groundwater, air, and food has engulfed as many as eighteen states in India, the problem being severe in Rajasthan, Andhra Pradesh, Jharkhand, Gujarat, and Karnataka where almost 40 to 90 percent population is affected in the problem districts. A recent study conducted by UNICEF on the extent of the magnitude of the Fluorosis problem indicated that approximately 25 million people in 213 districts in India are affected with Fluorosis and nearly 66 million including 6 million children below 14 years are at risk[1]. Drinking Fluoride contaminated water is the prime cause of fluorosis disease and the water analysis reports from different sources have revealed high fluoride concentrations in the range of 3 mgL-1 in groundwater supplies in the fluoride-affected areas. The maximum permissible limit of fluoride in drinking water is 1.5 mgL^{-1} as per the Bureau of India standards report (15-10500) in 1991 and also by the guideline of the World Health Organization (WHO)[2]. Though combating the menace of fluorosis is primarily the duty of the Government with the help of the major non-government bones, an effective solution to the problem is yet to be reached especially for the rural population.A good number of chemical laboratories spread throughout the globe are engaged in finding a suitable technology for the defluoridation of potable water. Until recently the popular methods of defluoridation of water were Co-precipitation and filtration (Nalgonda Technique)[3,] Absorption by activated alumina/carbon[4,] Ion exchange[5]and Revenge Osmosis[6]. However these are unable to solve the problem primarily because of the problem of unavailability of the materials used in the said processes in affected rural areas and their not being cost-effective. Moreover, handling of chemicals and reagents associated with aforesaid methods becomes unfriendly to the rural community. Against the above backdrop a browsing, cost-effective, and user–friendly pro-preventive solution has been developed by the present authors[7] to combat the menace arising out of fluoride ion that cripples the health and socioeconomic fabric of a major part of the country especially of the rural one. This is through the use of Poly aluminum chloride (PAC) and the introduction of a cost-effective and user-friendly technique for domestic defluoridation by co-precipitation and filtration methods effected in easy-to-design filters. Now sludge is produced from the water treatment land recommended in the present study. The quantity will be appreciable in case of a community plant and raw water is heavily contaminated with fluoride treatment of such sludge contaminated with high concentrations of fluoride is necessary from an environmental – safety point of view. The main purpose of this study is to sludge treatment disposal for suitable use and to present a scheme for using fluoride–iron sludge in brick making without any harmful effect of poisonous metals and bacteria thus preventing the environment from being further polluted by the fluoride content of the raw water de-fluoridated. Different aspects and prospects of these were investigated in the laboratory of the All India Institute of Hygiene and Public Health, 110 C.R. Avenue, Kolkata -700073.Unit Operations have been procured from some major brick–making concerns of the country. Sludge a bulk quantity of the same had been required, was collected from NIOH (National Institute of Occupational Health), and brick dust from brick making industry of Gujarat. To give the general acceptability different types of sludge were procured.

Proper Usage of Sludge from Fluoride Treatment Plants: The disposal of fluoride-rich sludge generated from the treatment processes (Employing the earlier techniques) is one of the issues that have received rather little attention from the sponsors of technologies and users[8]. Different treatment technologies are available at present, which might offer solutions to this menace viz Fluoride contamination in potable water and disposal of the sludge resulting in defluoridation problem possess among the processes of the defluoridation coagulation and co-precipitation (Alum, PAC coagulation, and Iron coagulation) and Sorption (Activated Alumina, Iron coated Sand and ion exchange resin) techniques are worthy of mention.

The precipitation process produces sludge with considerable fluoride content of up to 10% by weight. Uncontrolled disposal of the fluoride sludge would lead to pollution of the surface water and groundwater system and create severe environmental problems. Environmental regulations have become more stringent and the volume of sludge generated continues to increase, traditional sludge disposal methods (In reverse and ponds) are coming under increasing pressure to get changed. Incineration's are costly and contribute to air pollution and land-fill space is becoming scarce. A possible long-term solution appears to be recycling the sludge and using it for beneficial processes. It has been found that after such treatment hazardous waste gets solidified and stabilized and no longer hazardous. The solidified product is disposed of to a secure landfill site and recycled as construction material like bricks (figure 1) and has been found to leach pollutants within acceptable limits[9]

Effects of Using Fluoride Iron Sludge in Brick Making: Leaching of fluoride and iron from brick manufactured from fluoride, arsenic, lead, chromium, and iron sludge has been investigated in this study. 'Toxicity characteristics Leaching procedure (TCLP)' results show that leached species concentrations were far below.

Figure 1. Mechanical operation of sludge

The regulated TCLP limits and the quantities of the material leached out from sludge thus formed were less than those from dried sludge. Results of tests indicated that the proportion of the sludge and firing temperature are the two key factors determining the quality of the brick. Increasing of firing temperature and decreasing the amount of sludge in the brick resulted in a decrease in water absorption. The appropriate percentage of the sludge content for producing quality bricks was found to be in the range of 15 to 25% by weight with 15 to 18% optimum moisture content in the prepared mixture to be molded and firing at 1273k for 6 hours proved most satisfactory. This study has shown that fluoride iron and other toxic material sludge be used as brick material.

MATERIALS AND METHODS

Raw materials were collected Pankur, Jharkhand, and the Iron Treatment plant of Barasat, Habra, and North 24 Parganas of West Bengal. Some samples were also collected from NIOH, Gujarat. Collected samples were dried for 24 hours at 1323k. Basic physiochemical characteristics, including moisture content and pH, were also analyzed. Fluoride and iron content were determined digestion with a mixture of HNO_3 and HCL in a volume ratio 1:3.[9] Clay samples of normal bricks were collected from Mehninagar, Gujarat, and Barasat Ceramic and brick manufacturing area. It was ground with a crushing machine after collection because water content was an important factor affecting the quality of the brick. Mixtures with various proportions of sludge (5%, 15%, 25%, and 50%) and clay were prepared in batches (3 samples for each proportion). These were matured for 24 hours followed by another 24 hours at 1323k in an oven. The latter goes by the name 'oven-drying' period. Next, the mixture was heated in a carbolite heavy-duty electric furnace at temperatures 1223k, 1273k, and 1323k respectively for 6 hours. A total of 8 brick samples (length 25.4cm, width 12.7cm, and height 7.6cm) of the sludge-clay mixture in varying proportions (5%, 15%, 25%, and 50 %) at optimum moisture content (OMC) were prepared in laboratory. A clay-only sample was prepared as a reference specimen. All these samples were heated in a carbolite heavy-duty electric furnace at the design temperature 1223k, 1273k, and 1323k respectively for 6 hours. The produced bricks were subjected to a series of tests viz shrinkage on firing, loss of weight on ignition water absorption, and comprehensive strength to determine a suitable condition for producing quality brick.

Sludge and Clay Characteristics: Experimental results showed that the sludge has a p H of 6.6, indicating that the sludge would be treated as a neutral material. Fluoride content in raw sludge was almost double that in stabilized state. Further, it was observed that the total fluoride concentration in both types of raw sludge was much higher than in Environmental Protection Agencies (EPA)[10] [Table 1]. Soil samples collected were observed to be dark brown, silty-clay, highly plastic, and with no organic matter in it.

Table 1. Iron and Fluoride concentration (mg/kg) in sludge

Constituent	Concentration Present (mg/Kg) 378k oven Dry
Fluoride[1]	1325.6
Fluoride [2]	2245.2
Arsenic[1]	1604.2
Arsenic[2]	2485.3**
Iron[1]	11256.8
Iron[2]	17258.3
Lead[1]	0.012
Lead[2]	0.009
Chromium[1]	0.022
Chromium[2]	0.015

Note; 1. Stabilized sludge (from landfill site); 2. Raw Sludge (from Collection Pond); ** During ignition in the furnace at high temperature 1173k -1323k Arsenic Present if any gets volatilized and on analysis was found to be absent from the product obtained.

Brick Water Absorption: Absorption of water is a key factor affecting the durability of the brick (Figure 2). The less water infiltration in the brick, the more durable it is. The amount of water absorbed is directly proportional to the quantity of sludge added. An increase in the firing temperature resulted in a decrease in water absorption, thereby increasing the resistance. According to the criterion of water absorption of bricks, the percentage was below 17% for the first-class bricks and 17-20% for the second-class one.[11] According to this guideline bricks with 15% sludge burnt at 1233k-1273k will be in the first category and those 15% sludge and fired at 1323 fall in the second class category. Also bricks with 20% sludge fired at 1273k to 1323k will be in the second category[11].

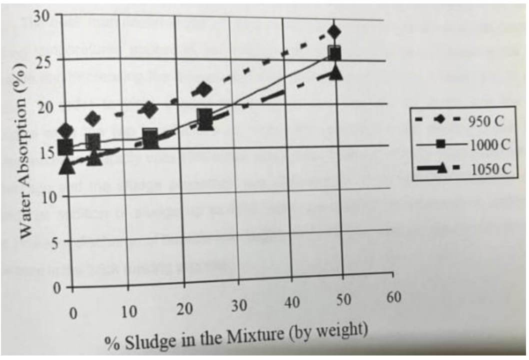

Figure 2. Water absorption of brick samples

CONCLUSION

This work demonstrated a feasible way of using fluoride and iron sludge as a clay substitute or a mixed component to produce bricks. Different measurements of both clay sludge mixtures and bricks were tried to evaluate the factors that could affect brick quality and strength. Fluoride content in the raw sludge was found to be almost double that present in the stabilized sludge. However, the optimum amount of sludge that would be mixed with clay to produce the good type of bricks was found to be 15% by weight, the firing temperature being 1273k. With up to 25% of sludge added to the bricks and fried at1773k, the strength would be as high as that of normal clay bricks. An increase in the amount of sludge added to the mixture results in a decrease in its plastic behavior. The brick manufactured did not show any deformation or unevenness of surface at any of the firing temperatures irrespective of variety in the proportion of sludge in the mixture. An increase in firing temperature and a decrease in the amount of sludge resulted in increasing water absorption. To yield a good quality brick the proportion of sludge and firing temperature were the two key factors controlling shrinkage during the whole process. Shrinkage on firing increased rapidly up to 15% of sludge in the clay sludge mixture. However, a linear relationship between the shrinkage and the sludge percentage was observed for 15 – 50% of the sludge added. It was revealed that the addition of sludge up to 25% retains the original characteristics of normal clay bricks. Quiet encouragement is the fact that discharge of Fluoride from such bricks made of clay sludge mixture and burnt at high temperature was found to have reduced largely depending of course on the firing temperature highest achievement is the same at 90% at the highest temperature.

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