Scholars Academic Journal of Biosciences (SAJB) **ISSN 2321-6883 (Online)**
Sch. Acad. J. Biosci., 2014; 2(5): 341-344 **ISSN 2347-9515 (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Laterite Soil as Low Cost Arsenic Adsorbent: A case study from Sahibganj District, Jharkhand.

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Abstract: The Arsenic contamination of groundwater has recently been reported from Sahibganj, Jharkhand, which is one of the most backward tribal dominated districts of India, causing immense hardships to the poor inhabitants of this area. The element arsenic is introduced into soil and groundwater during weathering of rocks and minerals followed by subsequent leaching and runoff. It can also be introduced into soil and groundwater from anthropogenic sources. These sources are localized and therefore, important in some geologic settings like recent alluvium in Gangatic Basin. The Ganga Meghna Brahmaputra Basin of which Sahibganj Dist. Is one of the worst Arsenic affected region of India. It occupies 569749 sq. km of area and about 500 million people are at risk and may develop various stages of arsenic poisoning, due to non-availability of safe drinking water. Long term exposure through drinking Arsenic contaminated water causes skin, lung, bladder and kidney cancer as well as pigmentation changes, hyperkeratosis, neurological disorders, muscular weakness, loss of appetite, and nausea. To provide for safe drinking water to the poor, the available technologies for water treatment are prohibitively costly as well as beyond the reach of rural people. The present study was undertaken to develop cost effective technique for water purification in Arsenic endemic zones of Sahibganj Dist. where laterite soil is naturally abundant as the cap rock in Rajmahal Traps. In this study Laterite soil has been tested as an adsorbent and proved to be a promising low– cost mitigation technique to bring Arsenic in drinking water within the permissible limits.
Keywords: Arsenic, Adsorbent, Laterite, Groundwater, Gangatic Basin.

INTRODUCTION

Long term exposure to arsenic in drinking water has variety of health concerns including several types of cancers, cardiovascular diseases, diabetes, and neurological effects [1-2]. Arsenic contamination has been reported from Bangladesh, India, Taiwan, Mongolia, Vietnam, Argentina, Chile, Mexico, Ghana and the United States [3]. The sources of arsenic in these countries are primarily natural rather than anthropogenic. Inorganic arsenic of geological origin has been recognized as the main form of arsenic contaminant in groundwater globally. Arsenic groundwater contamination was first detected in Sahibganj District of the Jharkhand state in the middle Ganga Plain, during December 2003–January 2004 [4]. A study on metal content (As, Fe, Ca, Mg, Mn, Zn, and Cu) in the groundwater of the Sahibganj district was also carried out by National Metallurgical Laboratory, Jamshedpurby [5] and UNICEF also studied arsenic in two blocks of the Sahibganj district in 2005 [6]. CGWB also studied the groundwater quality of this district and confirmed the occurrence of Arsenic contamination in groundwater samples [7].

Arsenic in groundwater has been reported, mostly in areas formed by recent alluvial sediments, in Holocene aquifers (less than 12 thousand years of age) of the Ganga-Brahmaputra fluvial plains [8, 4, 6]. Almost all the identified arsenic affected areas in Assam and Manipur are in the flood plains of the Brahmaputra and Barak, respectively [8,4].

Laterite Soil:

The term laterite [9] was first used to describe the morphological characteristics in the field settings to describe the typical geological formation comprising of brick stone, iron clay etc., to a rock mass produced due to in situ weathering of diverse pre-existing rocks of varied chemical composition[10]. Laterite has been variously described by different authors in geological literatures distinguishing it by various attributes like field settings [18] brick stone[9], Iron Stone [11], Red ferruginous clay [12], Indurated clay[12], Ferruginous banded clay[13]. etc.

Based upon mode of occurrence laterite is divided into (1) High level Laterite soil, (2) Low level Laterite[14] and (3) Plateau, terrace or valley laterite [13].

Origin of Laterite

The lacustrine origin [15-16] and fluviatile origin [13] have been proposed which refer to diverse geological environments. The marine origin of laterite[12] was proposed to account for sedimentary features associated with lateritic formations. Laterite has been claimed to be in situ product of alteration of underlying rocks [17-18].

During the twentieth century the research by the scientific community shifted towards the chemical properties, geochemistry of weathering and economic aspects of laterite.

The formation of laterite is primarily brought about by tropical weathering [19-20].

Characteristics of Indian Laterite

The Indian laterite is characterised by following features [10]

a) Large amount of iron, aluminium, and Manganese oxide and Titanium is present in varying proportions.
b) Indian laterite is mostlyfree silicadepleted.
c) Alkali minerals are found in negligible quantities.
d) The laterite usually hardens on exposure to air.

Mineralogy of Laterite:

Mineralogically laterite is essentially a mixture of varying proportions of goethite, hematite, gibbsite, boehmite and Kaolin [21].

Laterite Outcrop:

Majority of laterite outcrop are found to rest on trap flows in central part of Indian subcontinent and has been described as laterisation of Deccan traps [21]. The laterite caps are found to have uniform thickness resting on different types of gneisses, phyllites, mica schist, lime silicate rocks and quartzite. The laterite capping have formed due to in situ weathering of basalt[10].

Distributions:

In Indian subcontinent laterite is found in most rock types of age ranging from Eocene to Recent. The extensive laterite capping of Deccan Trap of Eocene age and Rajmahal formation of Triassic- Jurassic age, formed after the consolidation of basaltic lava flows.

Geological succession of Rajmahal Basin:

The Rajmahal Basin is situated in the Santhal Pargana Division adjoining West Bengal in East, and Jharkhand in West direction. McClelland first studied the geological section of Rajmahal (Sahibganj Dist.) region [22]. Oldham established the stratigraphy [23] and Ball mapped this area and proposed the following geological succession [24]:

Alluvium
Laterite
Gondwana system
Rajmahal Group
Dubrajpur Formation
Barakar Group (Damuda Series)
Talchir Group

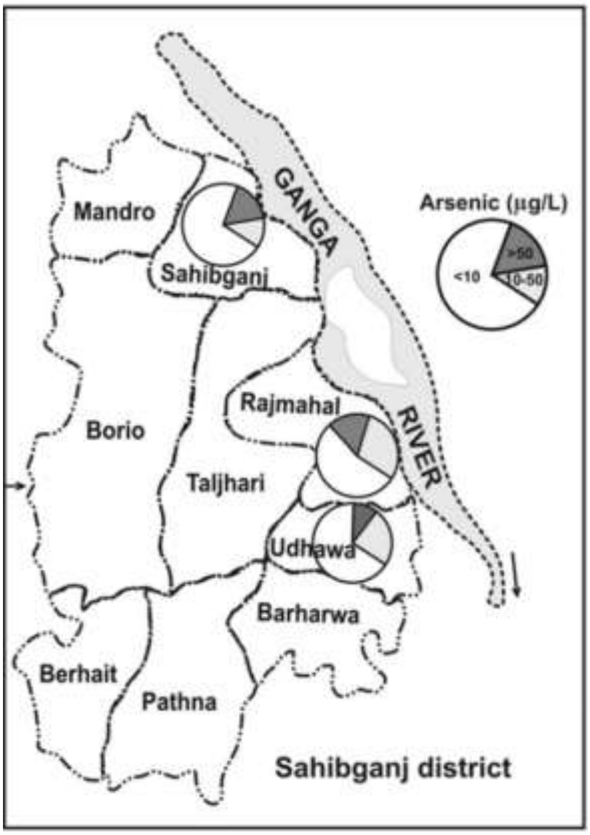

Fig-1: Arsenic contamination status in nine blocks in the Sahibganj district [25].

Significance of Laterite in Arsenic Mitigation:

The widespread occurrence of natural occurrence of laterite soil in and around Sahibganj District prompted the need for evaluating the Arsenic adsorption properties of this naturally occurring material [26-27]. Laterite soil has been tested as an adsorbent and proved to be a promising low– cost remedial technique to safeguard drinking water. Laterite is vesicular clayey residuum occurring abundantly in the tropical regions. Adsorption experiments showed that the removal efficiency varied between 50 and 90% for 5 g of added laterite per 100 ml water under an equilibrium period of 20 minutes. Modification of laterite by treating with 0.01 M HNO_3 increased the adsorption capacity of laterite due to an increased specific surface area[28].

METHODOLOGY:

The method used in studying the Arsenic adsorption properties of laterite from Rajmahal formation is based upon the field test principal to detect Arsenic by mercuric bromide stain method and retested by MERCK field test kit for semi quantitative analysis of water samples.The water samples used in this study were selected from three villages in Sahibganj district namely Dihari, Hajipur-Bhitta and Chanan. All the samples N=180 tested positive for Arsenic. The groundwater samples having tested Arsenic content more than 0.05 mg/L were subjected to laterite treatment to study the quantitative reduction in Arsenic content. The maximum permissible limit for Arsenic in drinking water (BIS 2003) is 0.05 mg/l. The Arsenic content above this limit is regarded as toxic.

Laterite soil was washed, hand crushed and sieved. The crushed laterite sample was added to Arsenic positive water samples to study the adsorption properties. A 20 gm. /l crushed laterite soil was added to water samples, steered and left for 1 hour. The samples were decanted after 1 hour and re tested for Arsenic.

After treatment, all samples were found to have substantially reduced Arsenic level demonstrating the effectiveness of laterite as a low cost and effective Arsenic adsorbent.

RESULTS OF THE STUDY

Table-1: Laterite Based Arsenic Mitigation.

Name of the Village	Arsenic (mg/l) Raw Water	Arsenic (mg/l) after Treatment with laterite soil
Dihari South (100 samples)	0.10 mg/l -.05mg/l	< 0.05 mg/l
Dihari North (50 samples)	0.05 mg/l	< 0.025 mg/l
Hajipur-Bhitta (25 samples)	>0.05 mg/l	< 0.025 mg/l
Chanan (3 samples)	0.05 mg/l	<0.025 mg/l
Chanan (1 sample)	0.1 mg/l	< 0.05 mg/l
Chanan North (1 sample)	.05 mg/l	< 0.025 mg/l

SUMMARIES AND CONCLUSIONS

To save millions of lives of people from arsenic poisoning it is important to detect the arsenic concentration in groundwater and also to provide a suitable, user friendly and cost effective arsenic removal process for the rural people in India and other developing nations. Unfortunately, the very first step towards prevention and arsenic testing is in great chaos. The instruments are expensive and require skilled person to operate.

At present, very few laboratories can provide reliable result. On the other hand removal technologies so far tried for the rural people have potential but not tested thoroughly for adoption. Most of the rural people are illiterate and theyhave no alternative for hand pumps and tubewells for water needs for everyday usage. So a change in their adaptation behaviour is also required along with more friendly and appropriate technology.

The study though preliminary in nature under field conditions is quite promising and for the first time demonstrates the use of laterite from Rajmahal formation as a potential inexpensive adsorbent. All the analysed samples show substantial reduction up to 50% in Arsenic content after laterite treatment. The Rajmahal traps around Sahibganj district is abound with lateritic soil. The use of laterite for Arsenic mitigation is most economically viable alternative in this impoverished tribal dominant area.

Laterite forming irregular patches is also found at several places to the west of Rajmahal hills from Suri (West Bengal) to Ganges and Mahuagiri hills in south and attains a thickness of upto 200 feet. These can be also used as cheap resource for Arsenic mitigation in worst affected Malda and Murshidabad districts of the adjoining West Bengal state.

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