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Influence of Arsenic on Soil Properties Irrigated with Effluent Water of Lalmatia Coalmines

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Abstract

The effect of soil properties irrigated with effluent water of Lalmatiya was investigated for three consecutive year from Jan. 2013 to Dec.2015. The concentration of Arsenic in effluents water samples of range from 0.202 to 0.535 ppm in summer season, 0.195 to 0.522 ppm in rainy season and. 0.202 to 0.570 ppm in winter season 2013, 0.195 to 0.501 ppm in summer season 0.185 to 0.498 ppm in rainy season and 0.181 – 0.500 ppm in winter season 2014 and 0.185 – 0.495 ppm in summer season, 0.180 to 0.485 ppm in rainy season and 0.180 – 0.485 ppm in winter season in 2015. Arsenic concentration in soil sample of Lalmatiy coal mine area range varied from 0.506 – 0.692 mg/100g in 2013, 0.501 – 0.710 mg/100g in 2014 and 0.501-0.695 mg/100g in 2015 respectively. Analysis data indicated that the appropriate management of arsenic effected soil and Arsenic contaminated effluent water might increase the Arsenic availability in soil. Which in turn, might aggravate the Arsenic contamination of crops grown.

Arsenic is a general protoplasmic poison and it affects all systems in the body. Arsine can cross placental membrane and is known to be teratogenic to animal. Arsenicals are known to be carcinogenic to lungs in humans. They may also lead to skin cancer through the initial skin lesions.

Arsenic is highly hazardous to human and animal health. Higher concentration of arsenic in soil sample depends upon soil texture.

Key words : Arsenic availability in soil and water, Coalmine area.

Introduction

Arsenic is highly hazardous to human and animal health. Arsenic is introduced into water through the dissolution of minerals and ores from Coalmine effluents, and from atmospheric deposition. Concentrations in ground water in some areas are some time elevated as a result of erosion from natural sources. The average daily intake of inorganic arsenic in water is estimated to be similar to that from food. In take from air is negligible. A provisional guideline value for arsenic in drinking water of 0.01mg/litre is established[1-3].

Widely accepted mechanism of arsenic mobilization in groundwater are still be established. However, based on Arsenic geochemistry, three hypotheses describing probable mechanisms of as mobilization in groundwater specially, with reference to Halocene aquifers like in West Bengal and Bangladesh, have been suggested[4-6]. These are :

(i) Mobilization of arsenic due to the oxidation of As-bearing pyrite minerals:

Insoluble as-bearing minerals, such as arsenopyrite (Fe As S), are rapidly oxidized when exposed to atmosphere, realizing soluble As-containing minerals is highly dependent on the availability of oxygen and the rate of oxidation of sulphide. The released As (III) is partially oxidized to As(V) by microbial mediated reactions. The chemical reaction is given by

$$FeAsS + 13\ Fe^{3+} + 8\ H_2O \rightarrow 14\ Fe^{2+} + SO_4^{2-} + 13\ H^+ + H_3AsO_4\ (aq.)$$

(ii) Dissolution of As-rich iron oxyhydroxides (FeOOH) due to onset of reducing conditions in the subsurface:

Under oxidizing condition and in the presence of Fe, inorganic species of As are predominantly retained in the solid phase through interaction with FeOOH coating on soil particles. the onset of reducing conditions in such environments can lead to the dissolution of FeOOH coating Fermentation of peat in the subsurface releases organic molecules to drive reducing dissolution of FeOOH, resulting in release of Fe^{2+}, As^{3+} and As^{5+} present on such coatings. The chemical reaction is given by:

$$8FeOOH - As_{(s)} + CH_3COOH + 14H_2CO_3 \rightarrow 8\ Fe^{2+} + As_{(d)} + 16HCO_3 + 12H_2O$$

Where - $As_{(s)}$ is sorbed As, and $As_{(d)}$ is dissolved As.

(iii) Release of a sorbed to aquifer minerals by competitive exchange with phosphate ($H_2PO_4^-$) ions that migrate into aquifers from the application of fertilizers to subsurface soil. The second mechanism involving dissolution FeOOH under reducing conditions is consider to be the most probable reason for excessive accumulation of As in ground water.

Taking into consideration all these factors the present study is aimed. The main features have been taken into account to analyse the concentration of Arsenic in effluents water and Soil.[8,10,14]

According to utility waste water of Lalmatia coal mines and its effect on the soil samples were collected from ten different sites of Lalmatia coal mines area during consecutive year from January 2013 to December 2015. Sample collection area and water logging areas are viewed in the fig. 1-3.

Locaiton Of Lalmatia Coalmine Area

Fig.:- 1

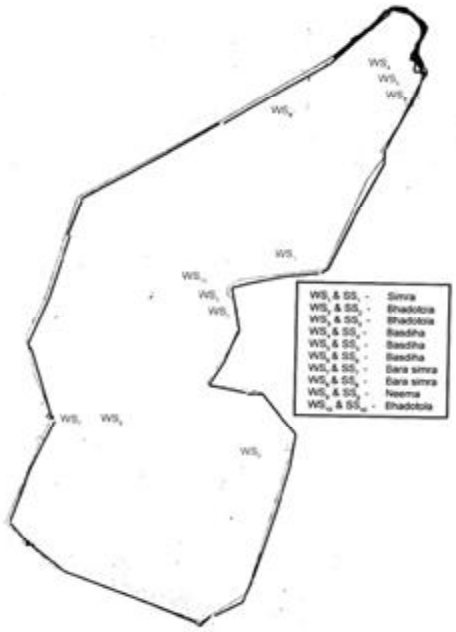


Fig :- 2

Coal Excavation Area Of Lalmatia Coalmine.

Fig : -3

Materials and Methods

All the chemicals are used were AR grade triple distilled water was used As analysis. The effluents water of Lalmatiya Coal mine area were collected in plastic bottles and preserved by adding 1.5ml of AR conc. HNO_3. The samples were analysed for As.

Arsenic present in the sample water reduced to AsH_3 which is directly aspirated into Ar-H_2 flame and measured in an atomic absorption spectrophotometer at 193.7 nm

Result and Discussion

Arsenic is a metalloid which is widely distributed in the biosphere. It is another chalcopile element and it accumulates in sulphide deposits and exist in nature mostly as sulphide ore.

The average abundance of As in the earth's crust is 1.8 ppm; in splids it is 5.5 to 13 ppm; in streams it is less than 2µg/L and 100µg/L. it occurs naturally in sulphide minerals such as pyrite. Arsenic is used in alloys with lead in storage batteries and in ammonication. Arsenic compounds are widely used in pesticides and in wood preservatives

Arsenic is nonessential for plants but is an essential trace element in several animal species. The predominant form between pH 3 - 7 is $H_2AsO_4^-$ and between pH 7- 11 it is $H_2AsO_4^{--}$ and under reducing conditions it is H_2AsO_2 (aq) or H_3 AsO_3. Aqueous arsenic in the form of arsenite, arsenate and organic arsenicals may result from mineral dissolution and industrial discharge.

The concentration of Arsenic in effluents water samples of Lalmatia coal mines have been tabulated in Table and its concentration range from 0.202 to 0.535 ppm in summer season, 0.195 to 0.522 ppm in rainy season and. 0.202 to 0.570 ppm in winter season 2013, 0.195 to 0.501 ppm in summer season 0.185 to 0.498 ppm in rainy season and 0.181 – 0.500 ppm in winter season 2014 and 0.185 – 0.495 ppm in summer season, 0.180 to 0.485 ppm in rainy season and 0.180 – 0.485 ppm in winter season in 2015.

It is evident from the table that arsenic content in water samples according to WHO the maximum permissible limit of arsenic in drinking water is .0.05 ppm[1]. So it is very clear there is much seasonal variation in arsenic content found in effluent sample. The average daily intake of inorganic arsenic in water is estimated to be similar to that from food[7]. Because of arsenic poisoning lakes of six districts of public of West Bengal suffering from various diseases they are using water from different source containing 1.5 ppm aresenic[8].

Arsenic is a general protoplasmic poison and it affects all systems in the body. Arsine (AsH_3) combines with haemoglobin and is oxidized to hemolytic compound that does not appear to act by sulphydryl inhibition. Low chronic doses of As ingested tend to accumulate in lipid rich tissues. High arsenic levels in man are usually found in hair nails and skin. When arsenic is inhaled it deposited in lungs and is netained in the lung tissues for a long time. Arsenic containing ointments or lipid soluble vesicants are absorbed through the skin. Non allergic contact dermatitis and conjunctivitis are frequently softened by workers exposed to arsenic containing dusts. Continued inhalation of arsenic dusts may cause perforation of the NASA/ spectrum as is the case with chromium and other metallic dust[9-10].

Arsenic can cross placental membrane and is known to be teratogenic to animal. Arsenicals are known to be carcinogenic to lungs in humans. They may also lead to skin cancer through the initial skin lessions[11]. Acute arsenic poisoning can arise from the ingestion of as 100mg As. Chronic effect can appear from the accumulation in the body at low intake level for prolonged periods. The usual level in portable water is within. 10 ppb; up to 100 ppb As has been reported[11].

Arsenic has been classified in the EPA'S Group A (human carcinogen) and it is regulated by the U.S. government. Arsenic is highly hazardous to human and animal health[12].

Arsenic concentration in soil sample of Lalmatia coal mine area range varied from 0.506 – 0.692 mg/100g in 2013, 0.501 – 0.710 mg/100g in 2014 and 0.501-0.695 mg/100g in 2015 respectively.

Higher concentration of arsenic in soil sample depends upon soil texture like phosphate[13]**.** The

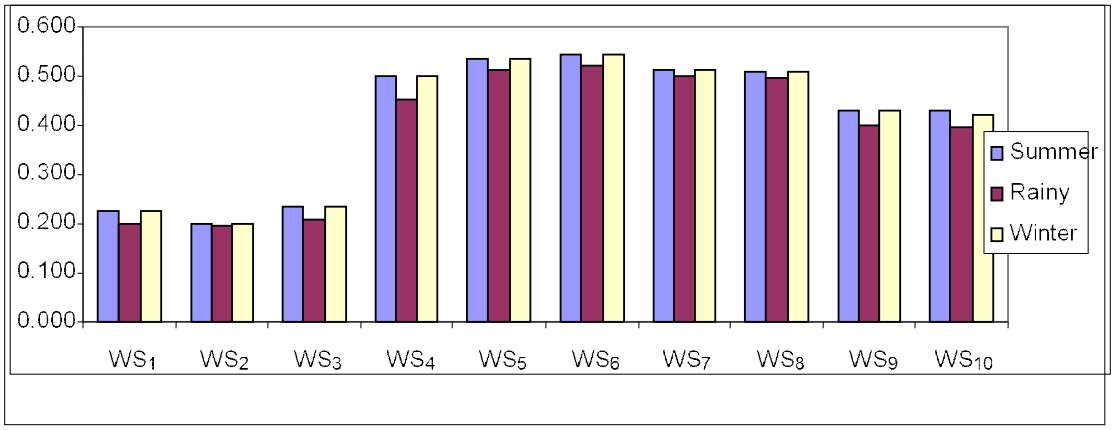
Table 1. Arsenic in Effluent Water Sample of Lalmatia Coalmine area
(Concentration of Arsenic in ppm.)

Season andyear	WS_1	WS_2	WS_3	WS_4	WS_5	WS_6	WS_7	WS_8	WS_9	WS_{10}
Summer 2013	0.225	0.202	0.235	0.498	0.535	0.545	0.512	0.510	0.432	0.430
Rainy 2013	0.200	0.195	0.209	0.452	0.512	0.522	0.498	0.496	0.398	0.40
Winter 2013	0.225	0.202	0.235	0.498	0.535	0.545	0.512	0.570	0.432	0.421
Summer 2014	0.215	0.195	0.200	0.428	0.501	0.501	0.501	0.490	0.401	0.438
Rainy 2014	0.212	0.185	0.196	0.418	0.495	0.498	0.498	0.462	0.401	0.418
Winter 2014	0.202	0.181	0.192	0.410	0.500	0.468	0.468	0.468	0.465	4.650
Summer 2015	0.210	1.850	0.190	0.425	0.490	0.490	0.495	0.480	0.401	0.425
Rainy 2015	0.200	0.180	0.185	0.420	0.475	0.480	0.482	0.485	0.385	0.420
Winter 2015	0.195	0.185	0.180	0.425	0.485	0.485	0.485	0.480	0.380	0.425

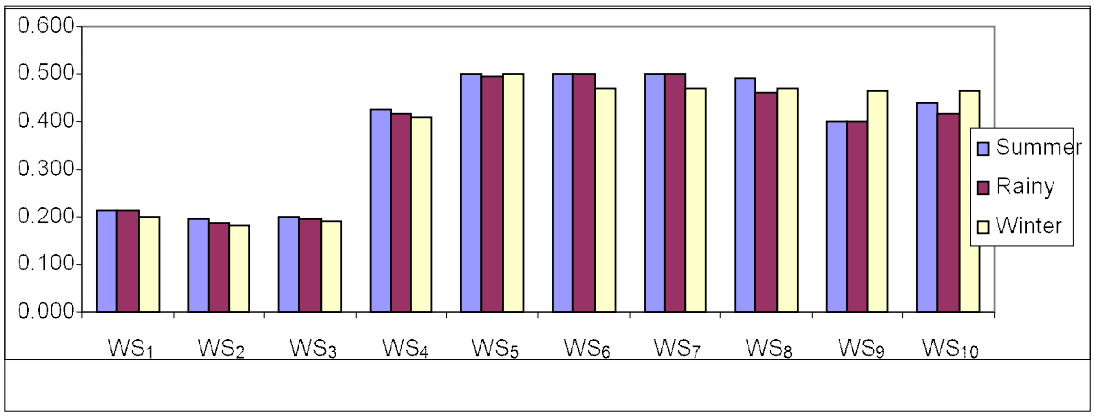
Table 1. Arsenic in Soil sample of Lalmatia coalmine area.
(Concentration of Arsenic in ppm.)

Season andyear	SS_1	SS_2	SS_3	SS_4	SS_5	SS_6	SS_7	SS_8	SS_9	SS_{10}
Summer 2013	0.602	0.605	0.604	0.676	0.692	0.698	0.712	0.642	0.609	0.622
Rainy 2013	0.592	0.562	0.586	0.660	0.689	0.696	0.665	0.506	0.578	0.522
Winter 2013	0.654	0.668	0.658	0.686	0.696	0.720	0.760	0.636	0.629	0.522
Summer 2014	0.502	0.602	0.601	0.650	0.680	0.665	0.710	0.610	0.609	0.615
Rainy 2014	0.552	0.525	0.565	0.650	0.675	0.685	0.650	0.501	0.565	0.502
Winter 2014	0.650	0.660	0.630	0.670	0.685	0.710	0.750	0.620	0.650	0.625
Summer 2015	0.501	0.598	0.597	0.620	0.650	0.660	0.690	0.590	0.509	0.605
Rainy 2015	0.540	0.520	0.550	0.640	0.665	0.650	0.640	0.501	0.540	0.490
Winter 2015	0.635	0.640	0.610	0.660	0.675	0.695	0.650	0.592	0.640	0.615

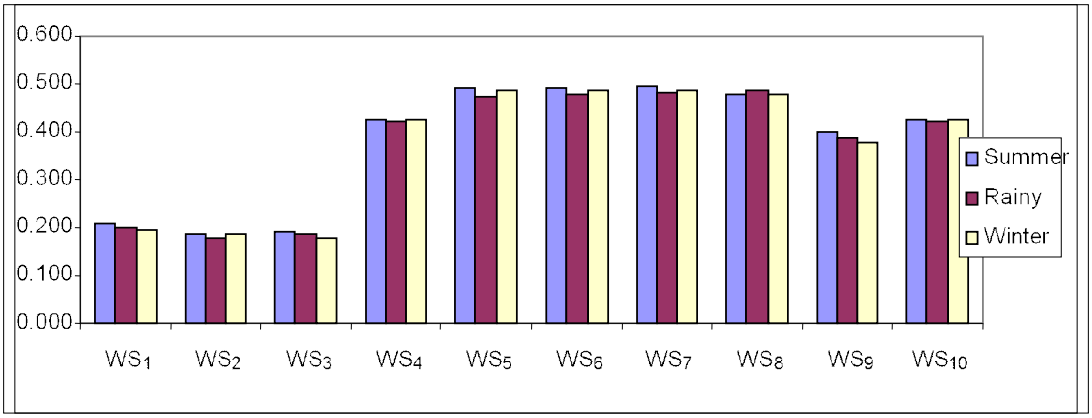
Graph -1
As (ppm) of Water Sample 2013



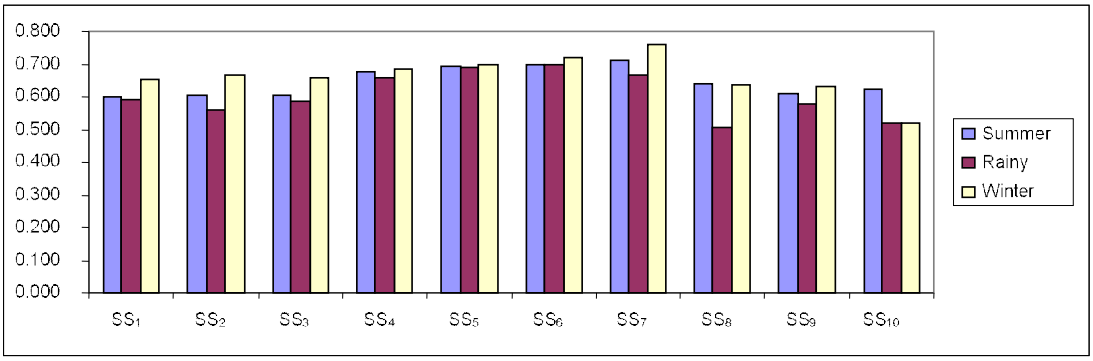
Graph -2
As (ppm) of Water Sample 2014



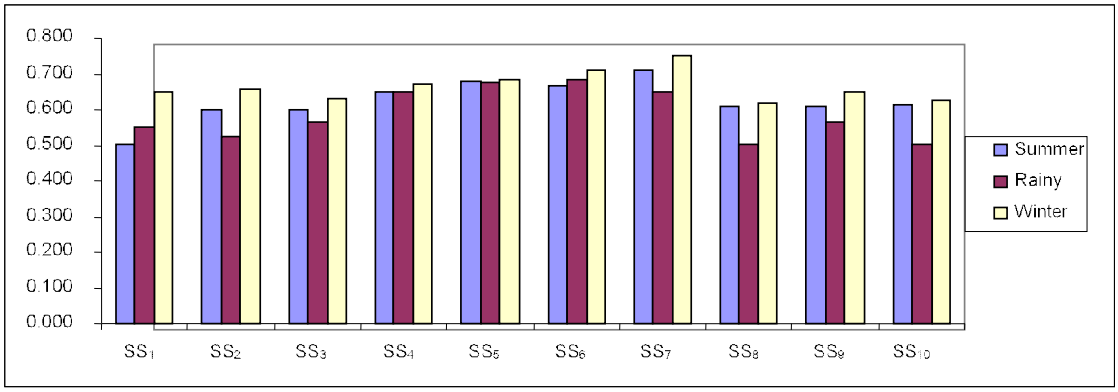
Graph -3
As (ppm) of Water Sample 2015



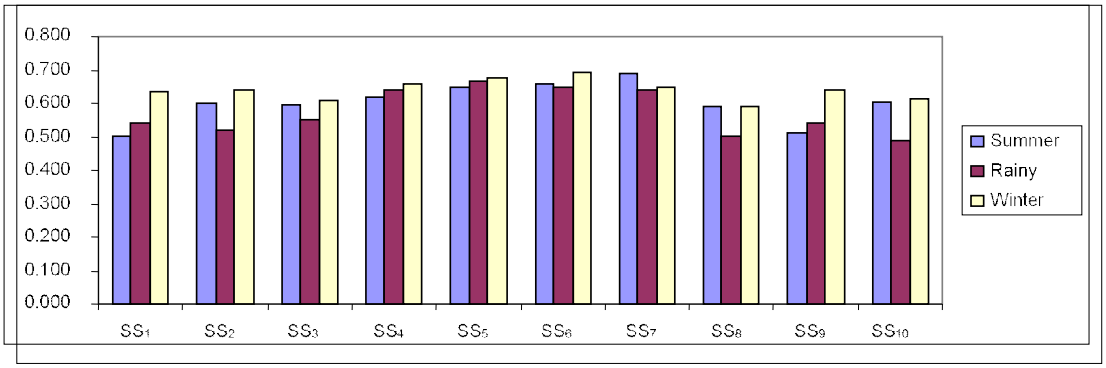
Graph -4
As (ppm) of Water Sample 2015



Graph -5
Average As (mg/100gm) 2014(soil)



Graph -6
Average As (mg/100gm) 2015(soil)



application of organic manure also cause considerable increase in available arsenic content of soil and soil moisture also played important role in governing the availability of arsenic in soil[12]**.** It is also interesting to note that with increase in soil salinity there was an increase in the available arsenic content in soil sample. The presence of salts in soil sample also aggravates arsenic accumulation in soil[13]**.**

Conclusion

Arsenic is a general protoplasmic poison and it affects all systems in the body. Arsine can cross placental membrane and is known to be teratogenic to animal. Arsenicals are known to be carcinogenic to lungs in humans. They may also lead to skin cancer through the initial skin lesions.

Arsenic is highly hazardous to human and animal health. Water containing arsenic is used for irrigation & thus plant uptake arsenic through soil. Higher concentration of arsenic in soil sample depends upon soil texture like phosphate.

Arsenic treatment technologies invented to remove the excessive concentration of arsenic to desirable level from the source of directly dependant on the geo-chemistry and existence of various species of arsenic in the natural environment. Ambient water chemistry of a particular region plays a pivotal role in invention of specific arsenic treatment devices should be based on the pilot- scale implementation of the technologies with objectives to improve ecfectiveness in arsenic removal, reduce the capital and operation cost of the system, to make the technology user friendly, overcome maintenance

problems and resolve sludge management problem containing arsenic contaminants more than permissible limit.

Lalmatiya coalmine is the biggest coal area which mainly ful-fills the demand of Farakka and Kahalgoan super thermal power of NTPC coalmine effluence may be harmful for agricultural land. So for checking adverse effect on soil properties other macro and micro nutrients may be analysed on seasonal basis.

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