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Predictive Study on Possible Metal Contamination for a Particular area Kendamari Jalpai of Nandigram District of West Bengal in the Virgin State

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Abstract: At present the global water resource is facing severe threat from overexploitation of it. More so, contamination of it due to various pollutants is making the situation worse. Out of the various forms of water sources, subsurface contamination leading to contamination of groundwater is a serious issue. On one hand the discharges of contaminants emanating from various industrial processes and contaminating the groundwater needs to be assessed and on the other hand, areas whose potential for industrial developments are strong, they also need to be assessed in the virgin state through some model study. The current paper tries to understand the probable dispersion of three toxic contaminants (arsenic, copper and chromium) in the subsurface of Kendamari Jalpai area of Nandigram, West Bengal. The area happens to have potential for industrial growth and hence the study in the virgin state. The study involved the collection of soil samples from the concerned area, their analysis, determination of permeability as one of the major aids for contaminant transport. A mathematical model has been used in the study to understand the dispersion pattern of these three toxic contaminants. The data reported a heterogeneous distribution of metal contaminants, with certain hotspots exhibiting significantly higher concentrations. The dispersion pattern was found to be influenced by several factors, including the geological characteristics of the area, soil pH, organic matter content, and anthropogenic activities. For instance, regions with higher clay content showed greater retention of metals, while areas with more organic matter exhibited increased mobility of contaminants. Additionally, groundwater flow patterns and seasonal variations played a crucial role in the dispersion of metal contaminants. During the monsoon season, the increased water flow facilitated the movement of metals from the surface to deeper layers, highlighting the need for continuous monitoring and assessment, especially in agricultural zones where groundwater is extensively used for irrigation.

Author Keywords: Toxic Contaminants, Groundwater, Virgin state, Permeability

I. INTRODUCTION

Subsurface contamination is an issue of utmost concern globally. On one side subsurface contamination is highly detrimental to the groundwater reserve and on the other hand, its dispersion pattern study is very much important for assessing its impact on the adjoining areas. In fact, subsurface contamination offers a challenge as far as its remediation measures are concerned. Researchers have carried out innumerable studies in which it has been found that in many

commercial, industrial, and military sites across the country, subsurface materials including groundwater are contaminated with chemical waste. In the contemporary global setting, emerging contaminants (ECs) are commonly observed in underground resources. They encompass a variety of pharmaceuticals, personal care products, consumer goods, surfactants, pesticides, and numerous industrial substances. The introduction of these substances into subsurface environments can occur via diverse routes following their release from residential, agricultural, and industrial zones. The other

contaminants of concern happen to be the metal contaminants which are discharged along with effluent from various industrial operations. In this regard, (Flick et al., 1969) reported the veracity of relatively high level of cadmium intake in a short period of time which triggers an acute response syndrome similarly to those signs that follow long-term intake or chronic syndrome. Acute response syndrome is normally characterized by severe nausea, salivation, vomiting, diarrhoea, abdominal pains, and myalgia and the associated pains range from mild to severe. Liver and/or kidney damage may happen to be the succeeding effect. The long-term low-level effects of cadmium following respiratory or oral intake are usually associated with industrial discharge and may be classified as an industrial hazard. (Fassett, 1975) reported the long term retention of small quantity of Cd absorbed, particularly in the kidneys triggering hypertension in many cases. (Chen et al., 2016) in his study focused on the evaluation of potential groundwater contamination risks in close proximity to a decommissioned landfill site with the primary objective of the study being to evaluate the landfill's influence on the quality of the surrounding groundwater and to offer insights into the movement and destiny of pollutants in the region. The research also illustrated the existence of substances like nitrates and heavy metals in the groundwater near landfill areas, suggesting a likelihood of contamination. In order to evaluate the risk of groundwater contamination near the decommissioned landfill, the researchers utilized a numerical simulation method through the utilization of the Groundwater Modelling System (GMS) software. The modelling procedure involved data gathering, development of a conceptual model, and numerical simulation. During the data collection phase, a variety of parameters such as yearly precipitation, evaporation, geology, hydraulic head, groundwater flow rate, and groundwater sampling chemistry were compiled. Subsequently, those parameters were utilized to construct a theoretical framework that served as the foundation for the computational analysis. (Lucatelli et al., 2018) conducted a study on the development of analytical methods for predicting contamination of aquifers. The main aim of the investigation was to examine whether a prudent selection of parameters would result in a reliable estimation of aquifer pollutants suitable for an initial screening or assessment. By comparing the outcomes of the models to real-world data collected from specific polluted locations, the study sought to validate their accuracy. The models not only replicated the distribution of contaminants but also calculated the total amount of pollutants discharged. (Sharma, 2015) conducted a study on the adverseness of cadmium. cadmium enters the atmosphere and adheres to minute particles, where it has the potential to react with water or soil, leading to the pollution of aquatic organisms, flora, and fauna in non-agricultural settings. The health ramifications encompass symptoms such as diarrhoea, abdominal discomfort, bone fractures, reproductive issues including infertility, harm to the central nervous and immune systems, as well as psychological ailments. cadmium, identified as a harmful metal, poses risks to both human health and biodiversity. It has been linked to the development of cancer in various tissues, as well as the encouragement of cell growth, hindrance of DNA restoration, and prevention of programmed cell death. Conversely, it triggers cellular demise, resulting in renal tissue impairment. The examination conducted by

Karthikeyan et al. (2010) scrutinized the influence of discharge from industries on the purity of subterranean water in Chromepet, Chennai, a locality abundant in leather industries. A total of thirty-six groundwater specimens were gathered in March 2008 and subjected to evaluation for chromium and copper content using an Atomic Absorption Spectrophotometer. Findings indicated that 86% of the samples exceeded the approved threshold for chromium, while 28% surpassed the copper threshold. The research underscores the adverse impact of waste effluents from tanneries on the groundwater quality within the area.

Multi-metal contamination in groundwater has become a significant environmental health issue worldwide. High levels of arsenic (As), fluoride, uranium, chromium (Cr), and lead (Pb) have been found in various aquifers, often due to human activities. The study of (Goswami et al., 2023) investigated As-Cr-Pb contamination in pristine aquifers of a hilly region with minimal human impact. Analyzing 22 groundwater and 6 sediment samples, it was discovered that all groundwater samples exceeded safe drinking limits for Cr, likely from natural sources. The water, characterized by rock-water interaction and mixed $\text{Ca}^{2+}\text{-Na}^+\text{-HCO}_3^-$ type, showed varying pH levels, indicating local human interference and weathering processes. While groundwater was mainly contaminated with Cr and Fe, sediments contained As, Cr, and Pb, suggesting potential groundwater risk. The study identifies pH changes as a key factor for Cr leaching and suggests that similar conditions may exist globally, warranting preventive investigations to protect communities. (Safiuddin et al., 2011) observed that groundwater arsenic contamination in Bangladesh is a major natural disaster affecting millions. Tube-wells, initially installed for safe drinking water, now dispense arsenic-laden water. Around 80 million people are at risk, with 30 million potentially exposed to arsenic poisoning. Symptoms like melanosis, keratosis, and hyper-keratosis are prevalent. Beyond health issues, arsenic affects crops and causes social problems. The severity, sources, and causes of arsenic contamination in Bangladesh are reviewed in this study, highlighting its health, agricultural, and social impacts. It also outlines urgent actions needed to address this crisis. (Jordao et al., 1997) evaluated chromium contamination from tannery discharges into rivers in Minas Gerais, Brazil, samples of sediment, vegetation, and fish were collected and analyzed using atomic absorption spectrophotometry. High chromium levels were found in these samples compared to controls, indicating significant contamination from tannery effluents. Sediments showed strong enrichment and high geoaccumulation indices. Vegetation samples contained more chromium than usual, and fish had chromium levels exceeding the Brazilian safety recommendation for human intake by 35 times. (Ishaku et al., 2010) examined seasonal variations in heavy metal contamination of groundwater in the Jimeta-Yola area. It aimed to identify how contamination levels change between dry and rainy seasons and assess the impact of human activities. Groundwater samples were collected from hand-dug wells and boreholes during both seasons. The samples were analyzed using a DR/2010 spectrophotometer, TDS/conductivity meter, and membrane filtration method. Results indicated increased levels of hexavalent chromium and copper during the rainy

season. The findings highlight the influence of anthropogenic activities on groundwater contamination by heavy metals. Copper toxicity in ecosystems was investigated by Akpomrere et al. (2020) as a global issue, necessitating the control of copper levels in the environment. In this study, 67 groundwater samples were collected from Delta State Polytechnic, Ozoro, at a depth of 90 cm during the rainy season in September 2019. Copper levels between 1.01 mg/L and 2.105 mg/L were found using an Atomic Absorption Spectrophotometer. Uneven copper distribution was shown by geostatistical analysis, with high concentrations in the North Eastern and central parts and low concentrations in the South Eastern part of the school. It was indicated by the study that waste dumps significantly affect groundwater copper levels. Proper waste disposal and groundwater treatment before human use were recommended. The assessment of groundwater quality in 22 wells located near the inactive Ingaldhal copper mine in Chithradurga, Karnataka, was conducted for potable purposes by Annapoorna et al. (2015). Standard methods were utilized to measure various parameters of water quality. The examination revealed the subsequent ranges: pH (7.61-8.34), EC (950-3120 μ S/cm), TH (410-1400mg/l), TDS (594-1913mg/l), F⁻ (0.15-1.43mg/l), NO₃⁻ (14-162mg/l), HCO₃⁻ (417-574mg/l), SO₄²⁻ (68-286mg/l), Ca²⁺ (59-150mg/l), Mg²⁺ (49-250mg/l), Na⁺ (38-290mg/l), and K⁺ (6-58mg/l). The dominant cations were observed to adhere to the sequence Mg²⁺ > Na⁺ > Ca²⁺ > K⁺, while the anions followed HCO₃⁻ > Cl⁻ > SO₄²⁻ > NO₃⁻ > Fe⁻ > F⁻ > CO₃⁻. A majority of the samples exceeded the drinking water guidelines established by national (BIS) and international (WHO, 2011) standards. Utilizing GIS, regions with acceptable groundwater quality were delineated. Rock and evaporation were both indicated as dominant factors by Gibbs diagrams, with 18% of the samples displaying high weathering and low evaporation rates, influenced by human activities. Analysis using Piper diagrams identified four hydrochemical types: Ca-Mg-HCO₃ (n=9), Ca-Mg-SO₄ (n=6), mixed Ca-Na-HCO₃ (n=6), and Na-Cl (n=1). In conclusion, the groundwater was deemed chemically unsuitable for drinking purposes (Zagury et al. 2003). A study carried out by Zagury et al. (2003) was centered on the presence of metal contamination in the vicinity of CCA/PEG-treated utility poles. A comprehensive analysis was conducted on 189 soil samples collected at different depths and distances around six poles located in Montreal, Canada, focusing on the presence of copper (Cu), chromium (Cr), and arsenic (As). Furthermore, the study evaluated various soil physicochemical properties. Groundwater samples underwent metal analysis and *Daphnia magna* bioassays. It was observed that sandy soils displayed lower levels of contamination in comparison to clayey and organic soils. The analysis revealed that copper levels were the highest, followed by arsenic and chromium. The concentrations of Cu (1460 \pm 677 mg/kg), As (410 \pm 150 mg/kg), and Cr (287 \pm 32 mg/kg) were most prominent near the ground line and in the immediate vicinity of the poles. As the distance from the poles increased, the levels of contaminants decreased, eventually returning to background levels within short distances of 0.1 m for Cr and 0.5 m for Cu and As. At a depth of 0.5 m, chromium and copper levels approached background concentrations. Arsenic levels near the poles were found to be three to eight times higher than Quebec's Level C criterion but decreased to 31 mg/kg at 0.1 m. The

presence of arsenic was detected up to a depth of 1 m (17–54 mg/kg). In groundwater samples, copper and chromium levels were <1.000 mg/L and <0.05 mg/L, respectively, with Cr(VI) <0.02 mg/L. Although one sample exhibited arsenic levels >0.025 mg/L, bioassays indicated a low ecotoxic potential of the groundwater. Various researchers such as Sarkar (2017), Pinder (1984), Marseguerra et al. (1997), and Sarma et al. (2021) have conducted studies along similar lines, focusing not only on the toxicity of different contaminants in groundwater but also on the development of models to comprehend their transport behavior. This study also aimed to investigate the potential transport mechanisms of three major toxic pollutants and their likely impact on the area in its original state. Given the anticipated industrial developments in the area, the importance of the research conducted is underscored.

Study Area

The location of Kendamari Jalpai (21°59'12.7068''N 88°1'44.202''E) has been chosen with the area offering huge viability to industrial developments and developing into a promising industrial hub ahead considering its locational advantage and transport connectivity. Kendamari Jalpai village is located in Nandigram-I subdivision of Purba Medinipur district in West Bengal, India. Tamluk and Nandigram are the district and sub-district headquarters of Kendamari Jalpai village respectively. The total geographical area of the village is about 789.45 hectares. Kendamari Jalpai has a total population is 7604, out of which male population is 4008 while female is 3596. Haldia happens to be the nearest town of Kendamari Jalpai for all major economic and commercial activities which is approximately 10 km away.

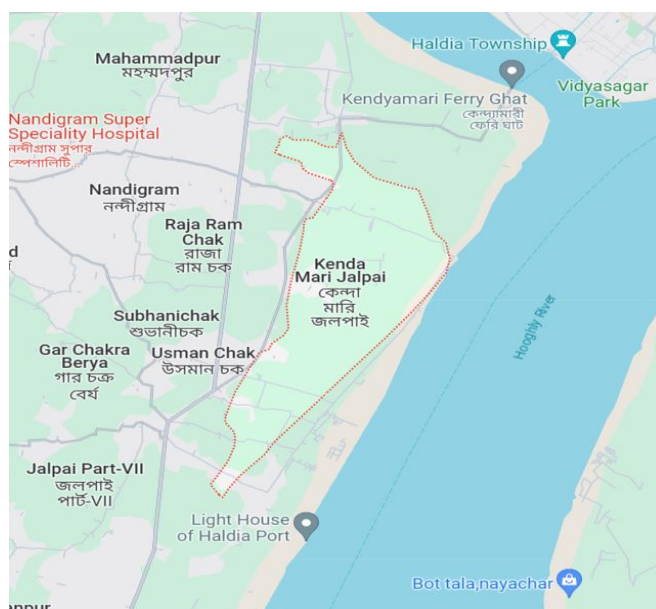


Fig.1: Study site

Contaminant Transport Model

The contaminant transport model has been developed on the basis of the “Remedial Target Worksheet”, a comprehensive tool designed to assist environmental professionals in assessing

and managing land contamination. This worksheet is grounded on the principles of hydrogeological risk assessment and follows the framework established by the Environment Agency's Remedial Targets Methodology, USA. The primary objective of this worksheet is to facilitate the derivation of site-specific remedial targets for contaminated sites where soil and/or groundwater have been impacted. It serves as a guide to evaluate the extent of contamination and to set clear, achievable goals for remediation efforts aimed at protecting the aquatic

environment and public health. The worksheet operates on a multi-tiered assessment approach, allowing for a progressive evaluation that considers various factors such as contaminant source, pathway, and receptor. This user-friendly tool is designed in Microsoft Excel 97™ and serves as an accessible and efficient platform for risk assessors to input data, analyse results, and make informed decisions regarding land contamination issues.

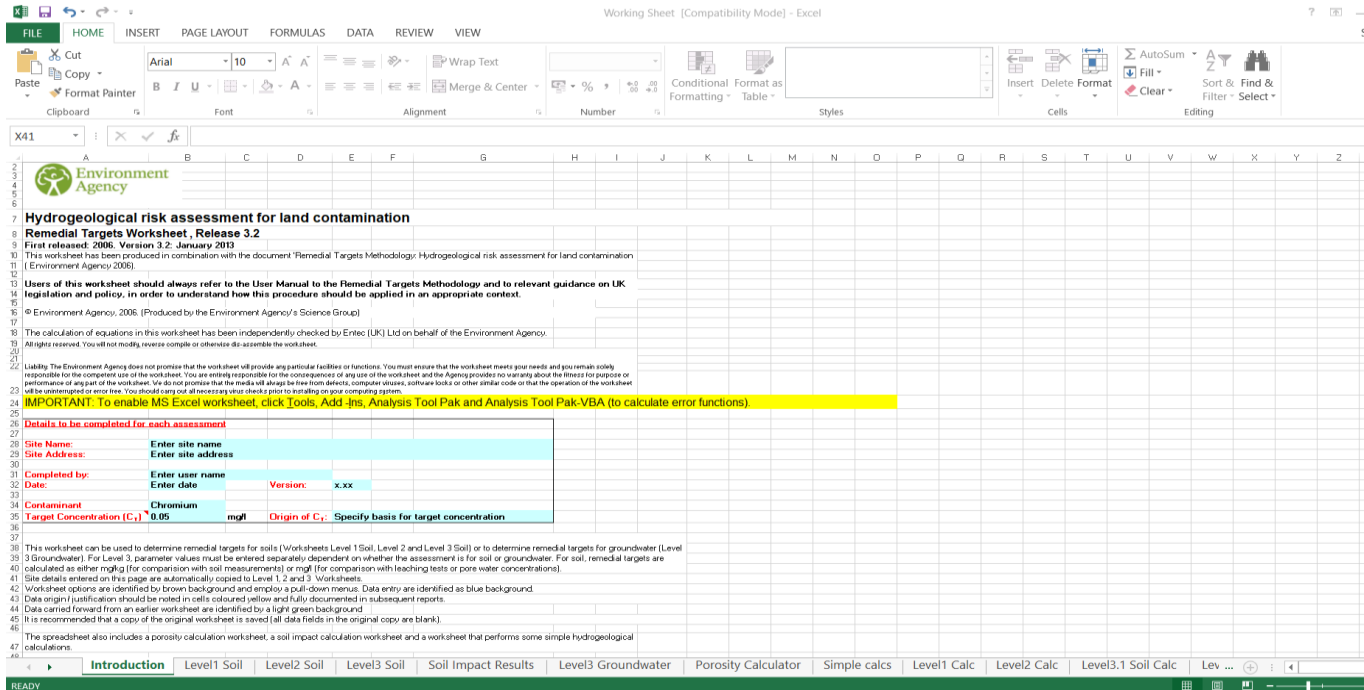


Fig. 2: Screenshot of the Working Sheet

II. RESULTS AND DISCUSSION

The current results and discussions are focussed on the probable input value of arsenic, copper, and chromium concentrations expected from possible industrial discharges in the area into the contaminant transport model for assessing their probable dispersion pattern in the subsurface in the virgin state. Within certain specified depth and lateral stretches, the study has been conducted to understand the spread of the contaminants concerned and also their probable concentrations. In general, for the study in the virgin state a total vertical depth of 10 m in interval of 2 m from the position of Ground water table and lateral stretch of (10-50) m in intervals of 10 m and (500-5000) m in intervals of 500 m for analysing the spread of the three metal contaminants As, Cu and Cr have been considered. The results obtained from the contaminant transport model for all the three metals have been represented accordingly in Tables 1, 2 and 3 respectively.

Contaminant As was input in the model subject to its standard concentration of 0.01 mg/l, permeability (K) value as reported for the site being 0.00003010176 m/day and infiltration rate of 0.0792 m/day for the area, it has been observed that for a depth of 2 m, up to the maximum lateral stretch of 50 m and also extending upto 5000 m, there is no

significant change in the highly low concentration of As reported. In order to understand the compatibility of the model for the particular area, slightly elevated values of permeability (3.5-4.4) m/day were also considered for the subsequent depths (4-10) m, but for all the depths and for all the lateral stretches very insignificant contamination potential for As was reported for the area concerned.

Regarding the trend in the variation of the remedial target concentration of As with respect to lateral stretches/ lateral expansion, the only thing to worry is the existence of some background concentration of the contaminant in the study area even in the virgin state, however small it might be (Refer Fig. 3a, 3b, 3c, 3d and 3e).

TABLE 1
Probable As Contamination Assessment

Depth (m)	Lateral Stretch (m)	Remedial Target Concentration
2	(10-50)	1.00E-02 mg/l or 1.38E-02 mg/kg
	(500-5000)	1.00E-02 mg/l or 1.38E-02 mg/kg
4	10	1.18E-02 mg/l or 1.62E-02 mg/kg
	20	1.09E-02 mg/l or 1.50E-02 mg/kg
	30	1.06E-02 mg/l or 1.46E-02 mg/kg
	40	1.04E-02 mg/l or 1.44E-02 mg/kg
	50	1.04E-02 mg/l or 1.42E-02 mg/kg
	(500-5000)	1.00E-02 mg/l or 1.38E-02 mg/kg
6	10	1.28E-02 mg/l or 1.76E-02 mg/kg
	20	1.14E-02 mg/l or 1.57E-02 mg/kg
	30	1.09E-02 mg/l or 1.50E-02 mg/kg
	40	1.07E-02 mg/l or 1.47E-02 mg/kg
	50	1.06E-02 mg/l or 1.45E-02 mg/kg
	500	1.01E-02 mg/l or 1.38E-02 mg/kg
	(1000-5000)	1.00E-02 mg/l or 1.38E-02 mg/kg
8	10	1.41E-02 mg/l or 1.94E-02 mg/kg
	20	1.21E-02 mg/l or 1.66E-02 mg/kg
	30	1.14E-02 mg/l or 1.56E-02 mg/kg
	40	1.10E-02 mg/l or 1.52E-02 mg/kg
	50	1.08E-02 mg/l or 1.49E-02 mg/kg
	500	1.01E-02 mg/l or 1.39E-02 mg/kg
10	10	1.52E-02 mg/l 2.09E-02 mg/kg
	20	1.28E-02 mg/l 1.76E-02 mg/kg
	30	1.19E-02 mg/l 1.63E-02 mg/kg
	40	1.14E-02 mg/l 1.57E-02 mg/kg
	50	1.11E-02 mg/l 1.53E-02 mg/kg
	500	1.01E-02 mg/l 1.39E-02 mg/kg
	(1000-5000)	1.00E-02 mg/l 1.38E-02 mg/kg

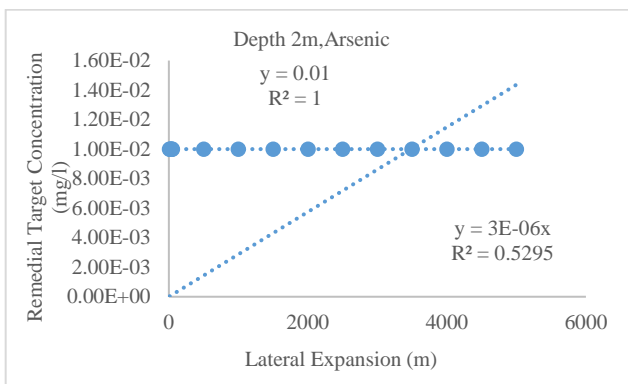


Fig. 3a

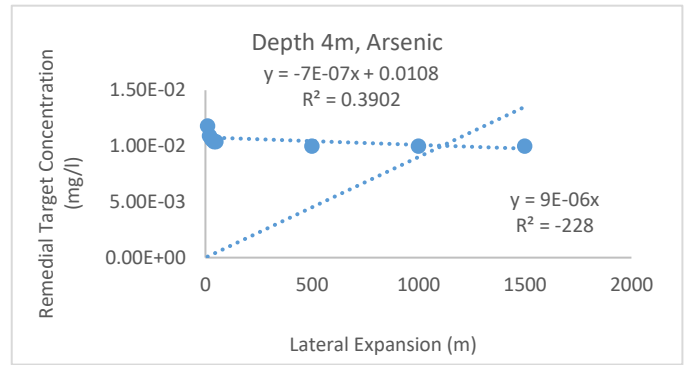


Fig. 3b

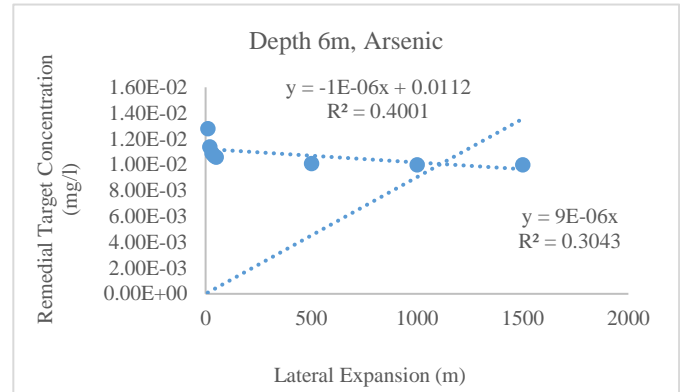


Fig. 3c

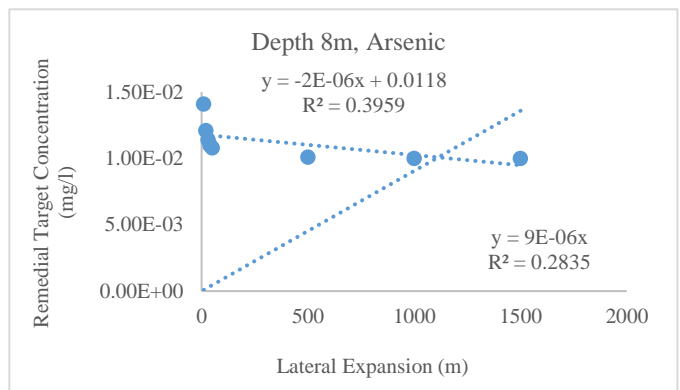


Fig. 3d

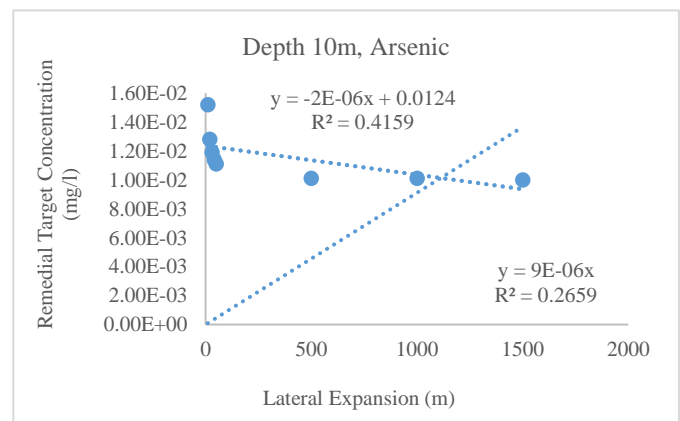


Fig. 3e

TABLE 2
Probable Cu Contamination Assessment

Depth (m)	Lateral Stretch (m)	Remedial Target Concentration
2	(10-50), (500-5000)	5.00E-02 mg/l or 6.88E-02 mg/kg
4	10	5.88E-02 mg/l or 8.09E-02 mg/kg
	20	5.44E-02 mg/l or 7.84E-02 mg/kg
	30	5.29E-02 mg/l or 7.28E-02 mg/kg
	40	5.22E-02 mg/l or 7.18E-02 mg/kg
	50	5.18E-02 mg/l or 7.12E-02 mg/kg
	500	5.02E-02 mg/l or 6.90E-02 mg/kg
	1000	5.01E-02 mg/l or 6.89E-02 mg/kg
	1500	5.01E-02 mg/l or 6.88E-02 mg/kg
6	(2000-5000)	5.00E-02 mg/l or 6.88E-02 mg/kg
	10	6.40E-02 mg/l or 8.80E-02 mg/kg
	20	5.70E-02 mg/l or 7.84E-02 mg/kg
	30	5.47E-02 mg/l or 7.52E-02 mg/kg
	40	5.35E-02 mg/l or 7.36E-02 mg/kg
	50	5.28E-02 mg/l or 7.26E-02 mg/kg
	500	5.03E-02 mg/l or 6.91E-02 mg/kg
	1000	5.01E-02 mg/l or 6.89E-02 mg/kg
8	1500	5.01E-02 mg/l or 6.89E-02 mg/kg
	2000	5.01E-02 mg/l or 6.88E-02 mg/kg
	2500	5.01E-02 mg/l or 6.88E-02 mg/kg
	(3000-5000)	5.00E-02 mg/l or 6.88E-02 mg/kg
	10	7.07E-02 mg/l or 9.72E-02 mg/kg
	20	6.04E-02 mg/l or 8.30E-02 mg/kg
	30	5.69E-02 mg/l or 7.82E-02 mg/kg
	40	5.52E-02 mg/l or 7.59E-02 mg/kg
10	50	5.41E-02 mg/l or 7.44E-02 mg/kg
	500	5.04E-02 mg/l or 6.93E-02 mg/kg
	1000	5.02E-02 mg/l or 6.90E-02 mg/kg
	(1500-4000)	5.01E-02 mg/l or 6.89E-02 mg/kg
	(4500-5000)	5.00E-02 mg/l or 6.88E-02 mg/kg
	10	7.61E-02 mg/l or 1.05E-01 mg/kg
	20	6.39E-02 mg/l or 8.78E-02 mg/kg
	30	5.93E-02 mg/l or 8.15E-02 mg/kg
40	5.69E-02 mg/l or 7.83E-02 mg/kg	
10	50	5.56E-02 mg/l or 7.64E-02 mg/kg
	500	5.06E-02 mg/l or 6.95E-02 mg/kg
	1000	5.03E-02 mg/l or 6.91E-02 mg/kg
	1500	5.02E-02 mg/l or 6.90E-02 mg/kg
	(2000-5000)	5.01E-02 mg/l or 6.89E-02 mg/kg

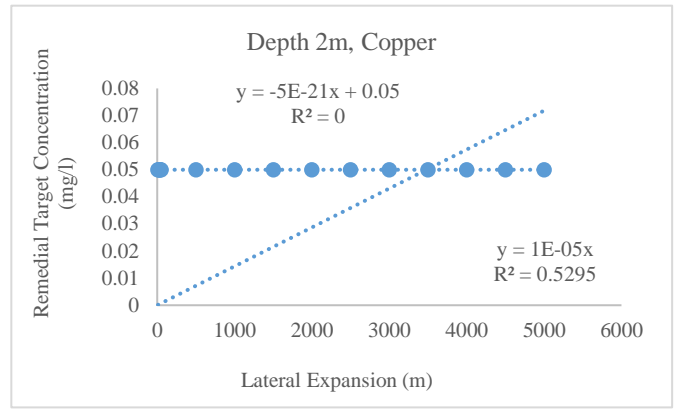


Fig. 4a

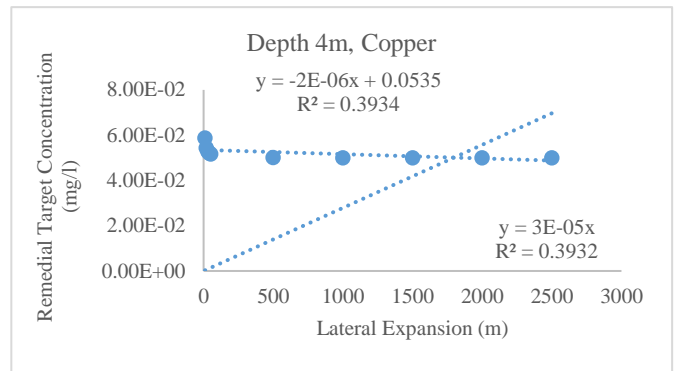


Fig. 4b

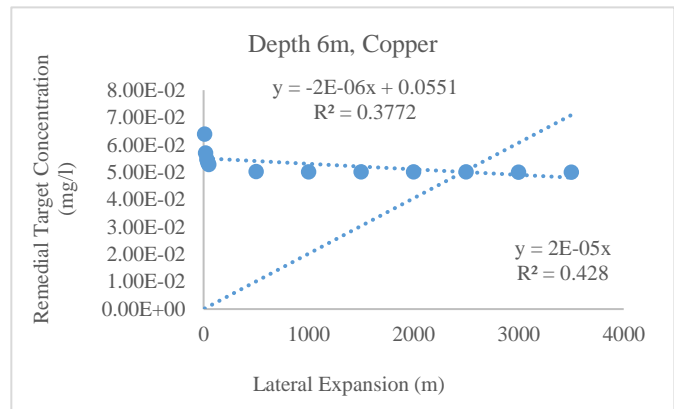


Fig. 4c

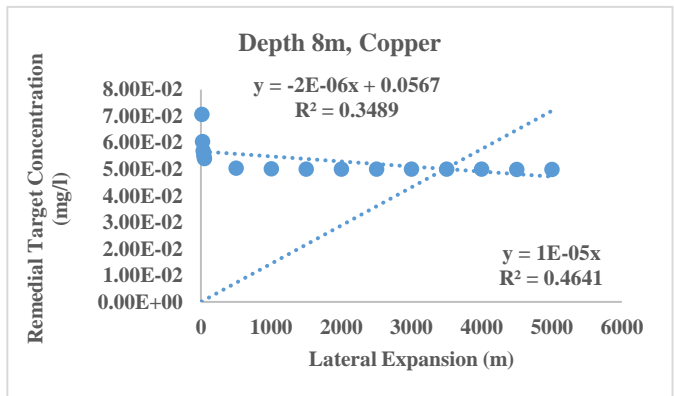


Fig. 4d

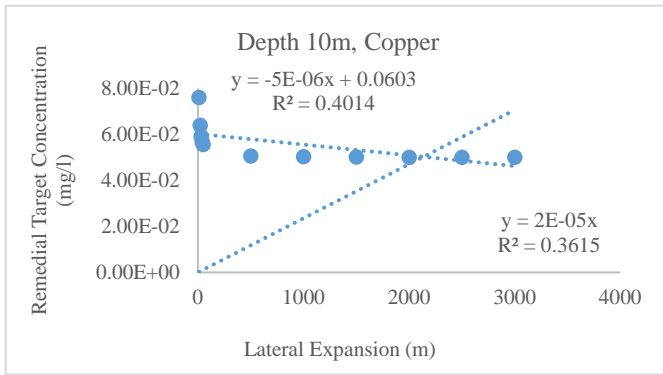


Fig. 4e

Figure 4: Remedial target concentration for copper (Cu)

TABLE 3
Probable Cr Contamination Assessment

Depth (m)	Lateral Stretch (m)	Remedial Target Concentration
2	(10-50), (500-5000)	5.00E-02 mg/l or 6.88E-02mg/kg
4	10	5.88E-02mg/l or 8.09E-02mg/kg
	20	5.44E-02mg/l or 7.84E-02mg/kg
	30	5.29E-02mg/l or 7.28E-02mg/kg
	40	5.22E-02mg/l or 7.18E-02mg/kg
	50	5.18E-02mg/l or 7.12E-02mg/kg
	500	5.02E-02mg/l or 6.90E-02mg/kg
6	1000	5.01E-02mg/l or 6.89E-02mg/kg
	1500	5.01E-02mg/l or 6.88E-02mg/kg
	(2000-5000)	5.00E-02mg/l or 6.88E-02mg/kg
	10	6.40E-02 mg/l or 8.80E-02 mg/kg
8	20	5.70E-02 mg/l or 7.84E-02 mg/kg
	30	5.47E-02 mg/l or 7.52E-02 mg/kg
	40	5.35E-02 mg/l or 7.36E-02 mg/kg
	50	5.28E-02 mg/l or 7.26E-02 mg/kg
	500	5.03E-02 mg/l or 6.91E-02 mg/kg
	(1000-2500)	5.01E-02 mg/l or 6.89E-02 mg/kg
10	(3000-5000)	5.00E-02 mg/l or 6.88E-02 mg/kg
	10	7.61E-02 mg/l or 1.05E-01 mg/kg
	20	6.39E-02 mg/l or 8.78E-02 mg/kg
	30	5.93E-02 mg/l or 8.15E-02 mg/kg
	40	5.69E-02 mg/l or 7.83E-02 mg/kg
	50	5.56E-02 mg/l or 7.64E-02 mg/kg
10	500	5.06E-02 mg/l or 6.95E-02 mg/kg
	1000	5.03E-02 mg/l or 6.91E-02 mg/kg
	1500	5.02E-02 mg/l or 6.90E-02 mg/kg
	(2000-5000)	5.01E-02 mg/l or 6.89E-02 mg/kg

From Table 2 it is observed that for the metal contaminant Cu having standard concentration of 0.05 mg/l, permeability value (K) of the soil being 0.000003010176 m/day and infiltration rate being 0.0792 m/day. Although at the initial depth of 2 m there is not so much variation in the contaminant concentration for lateral expansion up to 50 m from 10m and also from 500m to 5000m, but for the other depths ranging from 4 m to 10 m, there are certain variations as observed for the different intervals of the lateral stretches in the domain of (10-50) m and (500-5000) m. In this case also, the enhanced permeability values in the same range as done in the case of As, reported no significant enhanced contaminant transport in the lateral domain for the subsequent depths from 2 m. But the regression analysis for the remedial target concentration of Cu with respect to lateral expansion did indicate the presence of some background concentration of the contaminant even in the virgin state in the area (Refer Fig 4a, 4b, 4c, 4d and 4e).

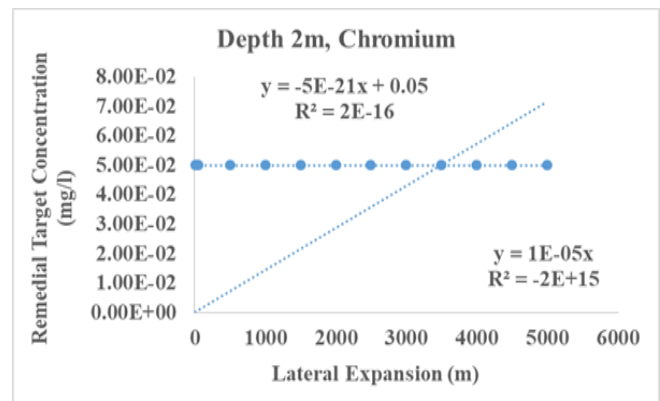


Fig. 5a

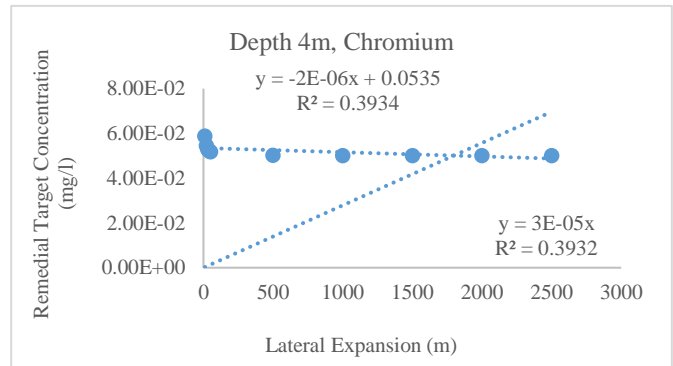


Fig. 5b

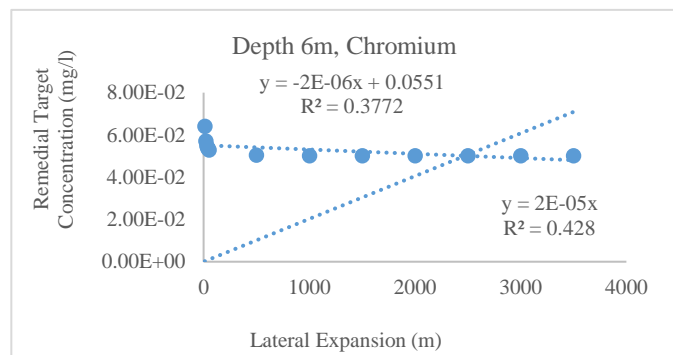


Fig. 5c

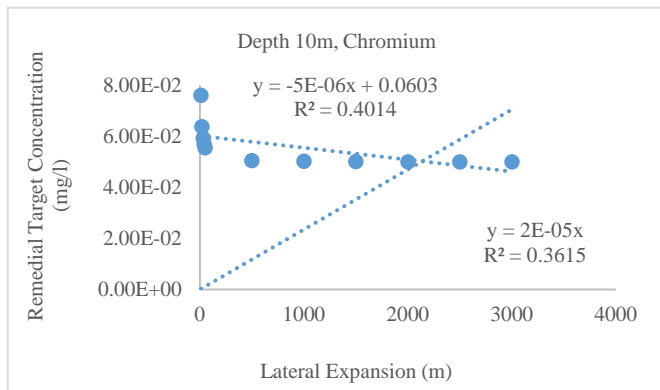


Fig. 5d

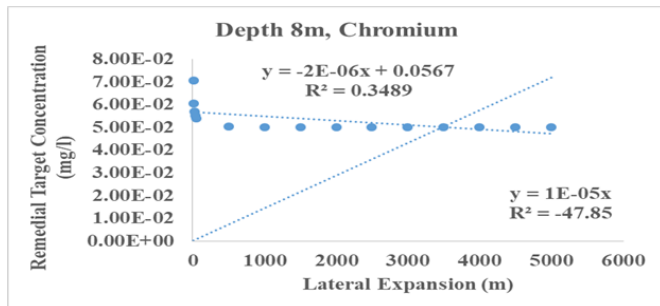


Fig. 5e

Figure 5: Remedial target concentration for chromium (Cr)

From Table 3, it is observed that though for higher depths beyond 2m for lateral expansions of (10-50) m and (500-5000) m certain variations in the concentrations of Cr are distinct but the overall concentrations reported are insignificant as compared to the permissible standard concentration of Cr (0.05 mg/l). Here also, even though the permeability values are slightly enhanced to see any distinct variations in the concentration of the contaminant, but the observations happen to be of not much concern. The regression analysis of Cr with respect to lateral expansions for various depths indicates the presence of background concentrations of Cr in the site even in the virgin state (Refer Fig, 5a, 5b, 5c, 5d and 5e)

III. CONCLUSION

The paper has reported on the insignificant concentration values of the three metal contaminants As, Cu and Cr for the study area. The area indeed happens to be in a virgin state and has the potential to develop into an industrial area in future. Considering this, with the linear trend for all the three metal contaminants being not applicable due negative R^2 value obtained when their concentration has been fitted with the lateral stretches for different depths of the soil, the other trend in occurrence of the metal contaminants is reported with some background concentrations. This is an alarming sign for the area as far as future industrial developments in the area is concerned. The study has paved the way to carry out further such contamination predictive studies for areas with industrial potential in the virgin state.

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