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Environmental Risks Due to Heavy Metal Pollution of Water Resulted from Coal Mining Wastes in Korba Chhattisgarh, India

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ABSTRACT

The mining waste facilities in the Dipka coal mining region of Korba are a result of coal extraction and coal washeries. Acid mine drainage (AMD), which poses a risk to the environment, particularly water resources, is a possibility when metal sulphide minerals from mining waste facilities are present. Some of the region's mining waste deposits include is close to residential neighbourhoods, agricultural regions, and surface water, and is situated close to the town of Dipka. The short migration. An enhanced environmental risk is being brought on by the pathway between the sources and the sensitive receptors. Metalloids and heavy metals like Pb, Zn, Cd, Cu, and Ni, are the principal pollutants present in the area. In the water samples taken from the area, their quantities were found to be over acceptable levels of contamination. In addition, substantial levels of heavy metals were detected in the groundwater coming from the settlements located downstream of the facilities for handling mining waste. Drinking water for people and pets as well as other agricultural uses (such as irrigation) are both done with the help of this water. The aim of the paper is to identify and analyse the most polluted water supply sources in the area and to draw conclusions about the environmental risk due to mining waste facilities. The results show high concentrations of heavy metals downstream of the waste facilities, leading to an increased environmental risk.

Key words: *Heavy metals, Water pollution, Environmental risks, Mining waste facilities*

Introduction

The mining sector is known to contribute significantly to environmental pollution, and mining waste dumps are known to contribute to long-term water and environmental contamination in general. Due to factors including their volume, high concentrations, and other factors, mining wastes cause environmental problems. Occupying enormous areas (expected to make up over 70% of all mining-related excavated material) (Younger *et al.*, 2002). Landscape damage, effects on ground and surface water, effects on local ecosystems, plants, and flora, as well as effects on people, are all factors. Acid mine drainage (AMD), which is high in sulphate ions, is created when metal-sulphide-containing mining waste dumps come into contact with ambient oxygen and humidity. Heavy metals (Pb, Zn, Cu, Ni, and Cd) can be disssolve, and mobilised by these acidic waters, transported, and released into the environment. The majority of the minerals found in mineral gangue, such as silicates, oxides, hydroxides, and

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carbonates, are found in mining wastes, along with polymetallic sulphides. The heterogeneous mineralogy of the wastes that contain sulphides causes chemical instability, which causes a number of chemical reactions to spontaneously begin when they are exposed to the environment's action. (Lottermoser, 2007). The most prevalent sulphide mineral and likely the most significant source of AMD is pyrite (FeS_2). The reactions used in the literature to describe the mechanism of pyrite oxidation (Lottermoser, 2007) are as follows:

$$FeS_{2(s)} + 7/2\ O_{2(g)} + H_2O_{(l)} \rightarrow Fe_2{}^{+}{}_{(aq)} + 2\ SO_4{}^{2-}{}_{(aq)} + 2\ H^{+}{}_{(aq)} + Q$$

$$Fe^{2+}{}_{(aq)} + \tfrac{1}{4}\ O_{2(g)} + 4\ H^{+}{}_{(aq)} \rightarrow 4\ Fe^{3+}{}_{(aq)} + \tfrac{1}{2}\ H_2O_{(l)} + Q$$

$$FeS_{2(s)} + 14\ Fe^{3+}{}_{(aq)} + 8\ H_2O_{(l)} \rightarrow 15\ Fe^{2+}{}_{(aq)} + 2\ SO_4{}^{2-}{}_{(aq)} + 16\ H^{+}{}_{(aq)} + Q$$

All of these reactions are exothermic. Depending on the pH of the solution, the oxidising agents may be ferrous ions (Fe3+) or ambient oxygen. With increasing pH, the concentration of the Fe3+ ion falls, and the precipitation of ferric hydroxide, $Fe\ (OH)_3$, limits its solubility.

$$Fe^{3+}{}_{(aq)} + 3\ H_2O_{(l)} \rightarrow Fe\ (OH)_{3(s)} + 3\ H^{+}{}_{(aq)}$$

The $Fe\ (OH)_3$ precipitate is a reddish-yellow colloidal suspension that is typical of acid mine water (AMD) (Fig. 1) and forms around mining waste dumps or mines (Younger, 1995). Usually, near mining waste piles during prolonged dry spells, the water's acidity and the concentration of metals released into the environment rise. The toxins may seep into the groundwater or may be carried by surface runoff to the surface waters (Gandy and Younger, 2008; Younger *et al.,* 2002), and may experience a variety of processes, including ion exchange, migration, accumulation, adsorption, transformation, dissolution, and desorption. (Wang *et al*., 2008). Due to the dispersed pollution produced in their surroundings, the regions covered by tailings dam facilities or mining waste heaps may be regarded as hot spots. The location of mining waste facilities in a specific area may make that area more vulnerable due to some physical-mechanical processes (possibility of tailing dam slipping or breaking) as well as due to some geochemical and physical processes (AMD generation, erosion, leakage, and air dispersion). (Álvarez-Valero *et al.,* 2009; Banks, 1997). There are multiple tailings dams or mining waste piles close to Dipka coal mining that are either newer or older and in various states of preservation. These piles of waste either contain fine or coarse tailings with a variety of particle sizes that are by-products of the mineral processing that led to the mining exploration and ore exploitation, accelerating the geochemical weathering processes.The water from the wells and hand pump located close to these mining waste facilities is used for irrigation of agricultural land as well as a source of drinking water for people and domestic animals. Thus, the presence of pollutants in groundwater provides a direct pathway of exposure for people and the environment, resulting in an increased danger to human health and an increased risk to biocenosis in the environment. The aquatic biota, along with agriculture, flora, and animals, are all at risk because of the contaminated surface water.

Fig. 1. $Fe(OH)_3$ in the stream from Dipka tailing ponds, August 2022

The purpose of the study is to detect and analyse the contamination of the surface and groundwater, downstream from the facilities that handle mining waste and are sometimes utilised for domestic purpose, usage, and to make some inferences about the environmental dangers by creating the following general objective: Investigation of the site, water sampling, instrument analysis, interpretation of the data, and a description of the conceptual environmental risk model

Case study- Description of the Study Area

Mining has been one of the primary occupations in the area since ancient times due to the region's substantial metal subsoil composition. Recent environmental impact assessment studies of Indian coal fields include the Raniganj in West Bengal (Das *et al.*, 2011), Pench Valley in Madhya Pradesh (Gupta, 1999) Jharia (Sarkar *et al.*, 2007) and Makum in Assam (Equeenuddin *et al.*, 2010). However, there are few rigorous environmental assessment studies of the Korba coalfield in Chhattisgarh, keeping in mind that it has the second largest coal reserves in India and provides 18% of the nation's coal requirements.

Geologically, Korba district of Chhattisgarh is dominated by rocks of Chhota Nagpur gneisses and Gondwana Supergroup, ranging from Archean to Carboniferous age (Mukherjee and Ghosh, 1998). The area is underlain by granite, granite gneisses, sandstone and shale with coal seams.

Since the last century, area mining gradually increasing according to the development of new techniques for ore processing. The soils in the Korba district are having wide variations. About 83% of the district area, is covered by yellowish to reddish Alfisols, These soils are derived from weathering of crystallines and metamorphic rocks. Coal dust is everywhere in Dipka – it turns the air hazy, the river water black and settles in a film on any surface left exposed for a couple of hours. "You can see the water in the river. Sometimes it turns black" Even cattle avoid entering in Lilagar, People living around the Dipka mine – the site is in the spotlight since it was flooded on September 29, 2019, after the Lilagar river flowing nearby changed its course – are exposed to critical levels of air and water pollution according to the villagers during a survey.

Table 1. Mean concentrations of metals in the groundwater from the Dipka coal region

S.No.	Rivers	Pb	As	Cr	Hg
1.	Hasdev River	0.01	0.01	0.05	BDL
2.	Lilagar River	0.013	0.02	0.04	BDL
3.	LakshamanNala	0.01	0.01	0.04	BDL
4.	Ahiran River	0.01	0.02	0.03	BDL
5.	Kholar Nala	0.01	0.02	0.02	BDL

All the values are in mg/L, BDL- Below detection limit

The development of mining activities led to the formation of tailing heaps or dams, which covered large regions. Even in the vicinity of the nearby town.

Experimental

The water samplings were conducted over the course of two campaigns, the first in August 2022 right after a dry summer and the second in May 2022, at the end of a wetspring. Heavy metals as Pb, As, Cr, were the primary contaminants discovered close to the mining waste facilities. The heavy metal concentrations in some of the groundwater and surface water samples near populated areas of the villages located downstream of mining waste facilities were over the contamination standards.

These river waters are often used for irrigation, while it can also be used for human or animal consumption. Surface water samples were collected from several rivers in the area, including Hasdev River, Lilagar, Lakshaman, Ahiran, Kholar Nala, as well as from other polluted creeks that were downstream of tailing dam facilities.

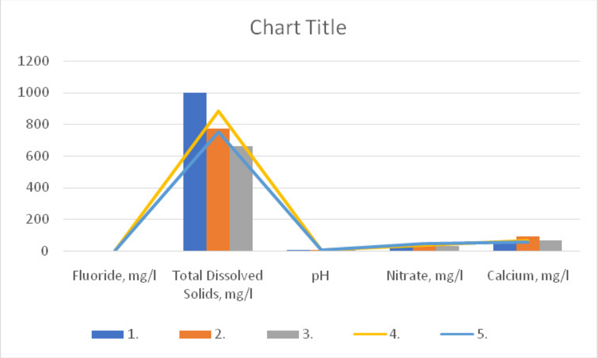

Fig. 2. Physico-chemical parameters in the water bodies

Table 2. Mean concentrations of metals in the waterbodies from the Dipka coal region

S. No.	Rivers	Fluoride, mg/l	Total Dissolved Solids, mg/l	pH	Nitrate mg/l	Calcium mg/l
1.	Hasdev River	1.88	1001	6.25	38.00	44.8
2.	Lilagar River	0.77	772	7.14	46.26	90.4
3.	Lakshaman Nala	0.30	662	6.72	28.26	65.4
4.	Ahiran River	0.52	882	6.52	38.26	65.4
5.	Kholar Nala	0.45	755	6.62	48.26	55.4
]

Fig. 2 show the increased TDS in Deo river, Lilagar and Lakshamannala

Results and Discussion

The analysis of the water samples

The analysed physicochemical parameters were pH, fluoride, TDS, nitrate and calcium. Their levels were compared with the permissible limits set by the CPCB (2006). Under the Water (Prevention and Control of Pollution) Act, 1974

Environmental risks

The environmental pollution generated by the mining activities and the mining waste facilities is continuous, even during the closure and post-closure phases of the mines, for a long period of time, over many decades (Coynel *et al*., 2007).

The exposure of mining waste to weathering effects can continue several decades or more, depending on the effectiveness of ecological restoration operations.Even if the mining waste heaps were properly restored, incidents such as water infiltrations or landslides could occur, causing environmental contamination.

As a result, the ecological rehabilitation of mining waste is a difficult topic for which the risk analysis approach may provide a solution. The pollutants harmful impacts on the environment and human health are determined by the toxicity, route, intensity, and likelihood of exposure. Pollution may have an impact on groundwater, surface water, soil, plants, and fauna (Ramirez Andreota *et al.,* 2013). Groundwater is an important source of drinking water, particularly for rural populations, and it can also be utilised for agriculture, as irrigation water for cattle, or for industrial purposes, as an industrial water resource (Rotaru and Raileanu, 2008). Consumption of contaminated water is a direct route of exposure for humans, which can result in major health consequences (Briggs, 2003). The risk is the probability that a pollutant may harm the population or the environment (Chon *et al.,* 2012; Panagopoulos *et al.,* 2009). The exposure of vegetation to soil contaminants is determined by the bioavailability ofthe pollutants (Hlihor *et al.,* 2009; Modoi *et al*., 2011), the pollutant concentration and the exposure time (Järup, 2003). Heavy metals are able to accumulate in living organisms (Chi *et al*., 2007), either directly through the consumption of contaminated water or indirectly through the consumption of contaminated plants or meat (Doðan-Saðlamtimur and Kumbur, 2010).

In this case study, the environmental risk assessment is based on a preliminary risk analysis. Comprising hazard identification (sample and chemical analysis), vulnerability identification, exposure pathways, and qualitative analysis of exposure likelihood. Fig. 12 depicts the conceptual risk model for mining activities in the dipka coal mining zone. A comparative investigation of the quality of unpolluted and contaminated water was undertaken to identify the influence of mining waste facilities on water quality, as well as to design a viable decision support system for the area's rehabilitation. Mining wastes and mining activities may present many exposure paths through which pollutants reach receptors, such as infiltration, leakage, surface runoff, and diffuse pollution, wind erosion etc. (Palumbo-Roe *et al.,* 2012).

The exposure of the receptors to contaminants may be exacerbated by the short distances between the pollution source and the receptor.

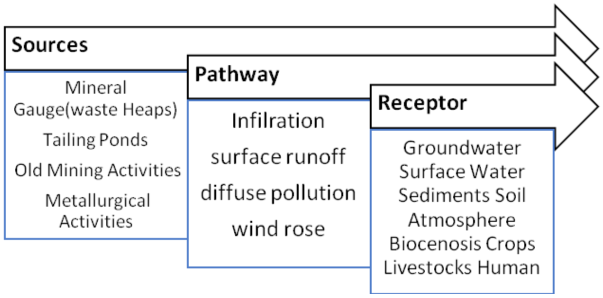

Fig. The conceptual risk model

Not only have mining activities polluted groundwater, but so have some agricultural activities (high concentrations of NO_3 in some groundwater samples and NH_4 in some surface water samples), particularly livestock stables in the courtyard, and problems with the sewer system for household wastewater.

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