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Case study on surrounding area of Barapukuria coal mine impeding soil fertility

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ABSTRACT: Coal is the world's most abundant and widely distributed fossil fuel source. As an energy resource of Bangladesh it's contributing a lot in the economy as well as a solution to the power starvation throughout the country. About two third of the population in North-western part of Bangladesh is making their livelihood by food production but the decreasing rate of production caused by the degradation of soil is an direct effect of the Barapukuria coal mine which is the only operating coal mine in the country. A survey on the area shows that a lot of farmers are changing their profession due to the loss of their labor and invest. This paper shows the effect of mine drainage water and other potential factors impelling dreadful conditions on soil at the neighboring areas of Barapukuria mine. Authors suggested a proper effluent system which can provide a supply of fresh water needed for irrigation and some special soil treatment methods that might be useful for the betterment of the agricultural lands.

KEYWORDS: BARAPUKURIA COAL MINE, CHEMICAL PERAMETERS, SOIL QUALITY, ECONOMY, REMEDIATION.

1. INTRODUCTION

Barapukuria coal mine has added a new dimension to the economy of Bangladesh as coal mine industry. This coalmine area has a reserved of about 390 mil ton. Nearly 4500-5000 tons of coal is extracting from this mine per day and this is using for energy sources specially power supply to the national grid. But in the 21st century the researchers revealed that the coal mine operation is a huge risk for the inhabitants as well as the surrounding environment of the coal mine area. The process of coal extraction from underground mining is complicated, leading to both direct and indirect impacts, or accidents, which often come without a pre-warning and create the mining sites vulnerable to environmental degradation.

Pollution of water bodies and soil with mine drainage is a major environmental concern worldwide. Underground coal mining waste, in general Acid Mine Drainage (AMD) is one of the factors which may cause serious environmental damage and social problems and may lead to major land-use problem and ecological issues. The generation of AMD can persist hundreds of years after closure of the mine and imposes toxic effects on surrounding environments.

Due to lacking of improper mine waste water disposal in Barapukuria, the environment is being ruined day by day. As coal mine discharge is frequently acidic and contains high concentrations of metals and metalloids; Soil moisture, fertility, microbiological changes, health etc. is affected for this problem. The low pH water dissolves and mobilizes metals from coal and residue deposits (Akcil&Koldas, 2006), and thereby adversely impacting on aquatic life and the surrounding vegetation (Cherry D.S.et al.2001). Although there are waste disposal systems in the mine operations but it does not qualify for the international standards.

The present study is, therefore, carried out to provide the distribution of the contamination in the surface water and agricultural soils, operational guidelines and procedures to mitigate the potential damages to humans and the environment that can result from mine waste water disposal in the vicinity of the Barapukuria Coal in northern part of Bangladesh (fig 1).

Fig-1 satellite image of the Barapukuria Coal Mine area

2. METHODOLOGY

Inspected area

The study was inspected in Barapukuria coal mine area to gather information about both surface water and soil condition using mainly chemical parameters and previous data collection. Some physical parameters have been also judged that was collected from previous investigation. Both water and soil samples were collected from the mine area and a short description of those samples are given below in table 1.

Table 1: Location and remarks of collected samples

NAME OF SAMPLES	LOCATION OF SAMPLES	REMARKS
SWS:01	88.9627E, 25.546N 31m elevations	Collected from just after water treatment
SWS:02	88.9587E, 25.5453N 32m elevations	First point of drainage water from BCMCL after water treatment, lots of local people are collecting coal dust from the flowing water.
SWS:03	88.9641E, 25.5446N 23m elevations	Water has taken from farming land, fertilizer may be used
SWS:04	88.9571E, 25.5431N 21m elevations	Farming land
SWS:05	88.9569E, 25.5423N 21m elevations.	Not flowing water
SWS:06	88.9678E, 25.5481N 15m elevations.	Water colour become darker and cloudy, not current

2.1 CHEMICAL PARAMETERS

The chemical parameters of the collected samples have been measured from laboratory analysis and the measured ranges of ions are shown below in table 2.

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Table 2: Ranges and possible causes of ions

IONS		RANGES (ppm)	MAXIMUM POINTS	POSSIBLE CAUSES
CATIONS	Sodium (Na^+)	18.451 -35.5	Surface water	Natural agencies (storms, high tide and saltwater intrusion) and weathering of feldspars and micas
	Calcium (Ca^+) Magnesium(Mg^+)	29.9-50.64 5.65-14.65	Surface water Underground water	CO_2 and organic acid generation in soil zones by root respiration and bacterial decay of organic matter
	Potassium(K^+)	5.13-17.56	Drainage water from Gondwana Fm	Weathering
	Manganese(Mn^{2+})	0.042-0.8	Drainage water from coal face	Drainage water of coal phase
	Iron(Fe)	0.56-7.5	Coal bearing water	Oxidation of pyrite
ANIONS	Bicarbonate(HCO_3^-)	91.5-167.75	Surface water	CO_2 released by the organic decomposition
	Chloride (Cl^-)	17.75 – 53.25	Surface water	Major constituent in natural water
	Sulphate (SO_4^{2-})	11.21 – 34.1	Drainage water from coal phase	Break down of organic substances and leachable sulphates from fertilizer and some human influences , oxidation of sulphide ores, gypsum, anhydrite
	Nitrate (NO_3^-)	0 - 35	Drainage water from coal phase	Nitrogen fixing plants (legumes) and bacteria, chemical fertilizers, sewage and decaying organic

The concentration of the ion shows that the greater range in surface water than the subsurface water. As a consequence, Surface water becomes more polluted than subsurface water that may adversely affect on soil quality and also the adjacent environment. The causes of this higher range of ions is due to the using of toxic elements in the treatment of waste mine water. The treatment plant is also insufficient for this mine area. Thus the concentration of ions gradually increases and it varies with distance from its source point. This variation is better to see in box and whisker plot (fig 2 –fig 7).

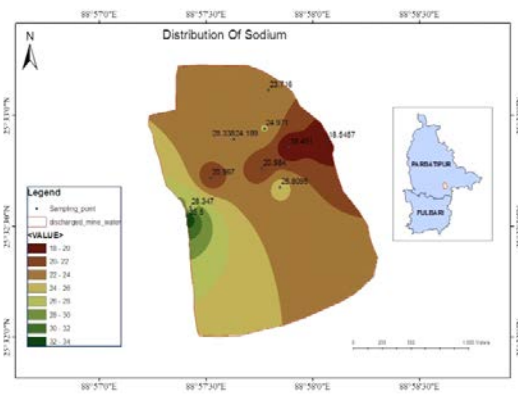

Fig 2: Distribution of sodium ion (Na^{+})

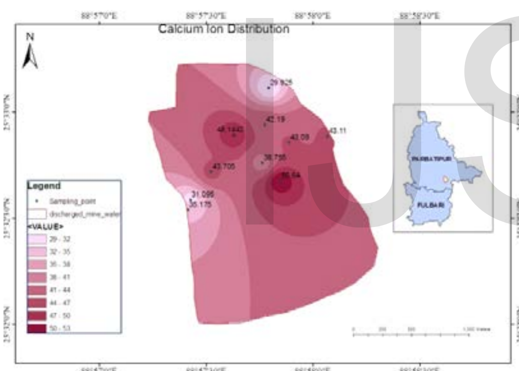

Fig 3: Distribution of calcium ion (Ca^{2+})

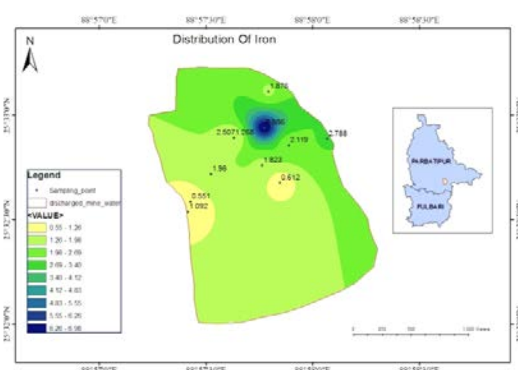

Fig 4: Distribution of iron (Fe^{2+})

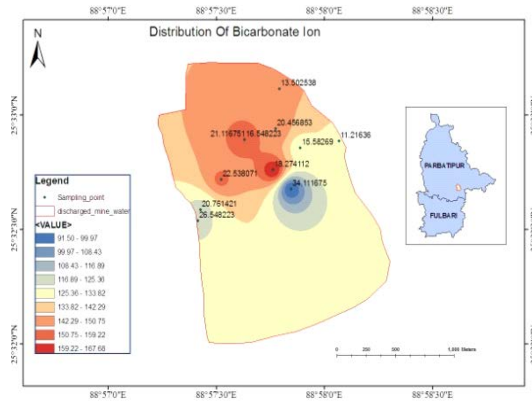

Fig 5: Distribution of bicarbonate ion (HCO_3^{-})

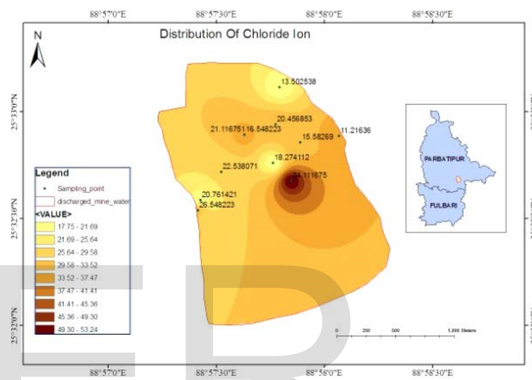

Fig 6: Distribution of chloride ion (Cl^{-})

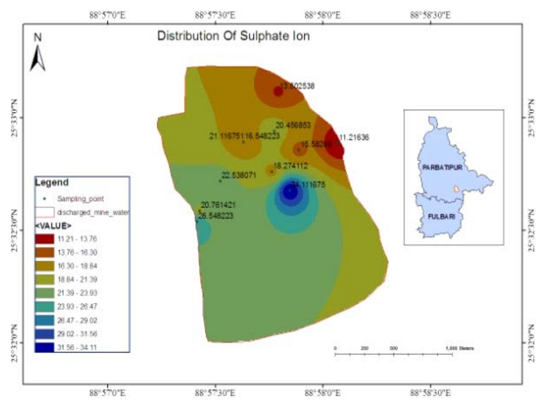

Fig 7: Distribution of sulphate ion (SO_4^{-})

2.2 PHYSICAL PARAMETERS

Physical parameters of that region have also been conducted to qualify the water that has been retaliated withprevious investigation of different authors. The ranges of parameters are shown below in table 3.

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Table 3: Ranges of physical parameters

Physical parameters	Source points	Ranges
Ph	Surface water	6 to 7.4
	Subsurface water	5.5 to 6.5
Ec (µs/cm)	Surface water	366 to 465
	Subsurface water	290 to 439

Some previous soil data has also been collected to compare the chemical and physical parameters of soil and water. Ranges of these parameters are shown in the following tables (table 4, 5 & 6).

Table 4: Data of chemical component of soil(Source: Md. J. B. Alam& A. A. M. Ahmed)

Chemical Components	Ranges
MgO (%)	0.7
CaO (%)	0.2
Na_2O (%)	0.2
K_2O (%)	0.2
B_2O_3(%)	42.7
Mg2+ (mg/L)	0.1
Ca2+ (mg/L)	0.2
K+ (mg/L)	0.2
Na+ (mg/L)	1
B3+ (mg/L)	<0.1

Table 5: data of physical parameters of soil (Source: Md. J. B. Alam& A. A. M. Ahmed)

Physical parameters	Ranges
Ph	6.5
Ec (µS/cm)	12.7

Table 6: Test result of coal and soil sample. (Source: Md. J. B. Alam& A. A. M. Ahmed)

Name of test	Coal sample (%)	Soil sample (%)
TOC	48.8	32

3. INTERPRETATION

Some graphical representations are used for a precise interpretation. On the basis of this graphical representation, the distribution of ions and a short description about their variation are given below (fig 8-fig 10). In the following bar diagram, the concentration of ions is expressed as mg/L and in piper diagram, it is expressed as meq/l.

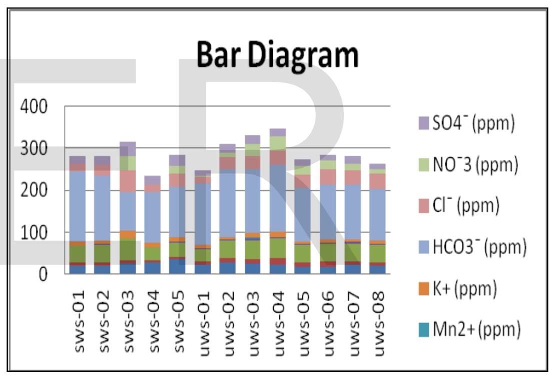

Fig 8:Bar diagram showing the variation of the concentration of ions

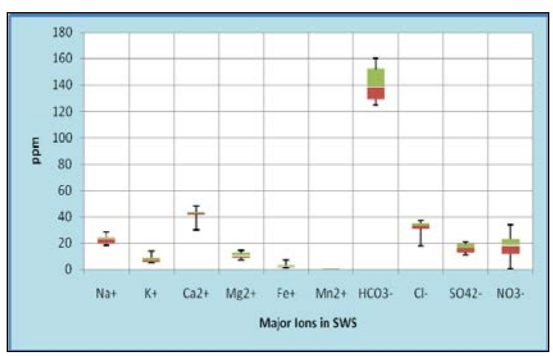

Fig 9:Box-and-Whisker plot showing the total concentration of ions

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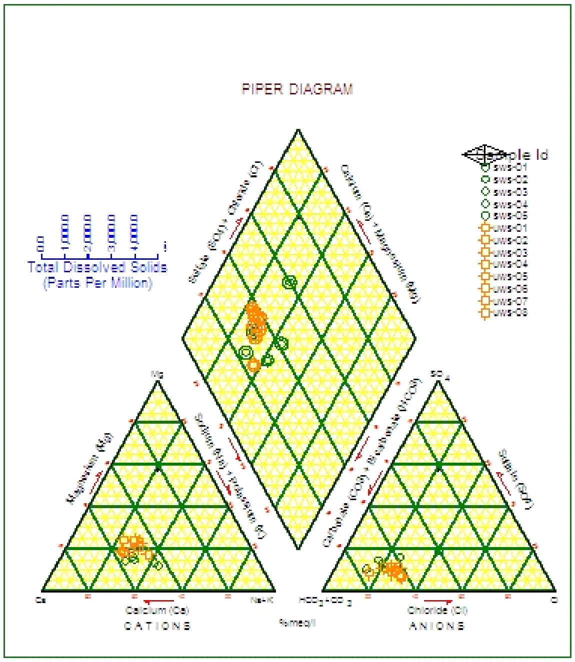

Fig10: Piper diagram showing the major ion concentration

From the above analysis, it has been seen that the mine drainage water is predominantly Ca-Na-HCO3– type. The major anion trend for mine drainage water is HCO_3^->$(Cl)^-$>$(SO_4)^{2-}$>(PO4)3– and major cation trend is Ca^{2+}> Na+ > Mg2+–> K^+. Concentrations of dissolved HCO3– reflect the degree of water–rock interaction in groundwater systems as well as integrated microbial degradation of organic matter.

Impacts on environment and soil:

By releasing of heavy metals which are associated with coal such as aluminium (Al^{3+}), zinc (Zn^{2+}) and manganese (Mn^{2+}), AMD is affecting directly and indirectly on the Environment and Ecosystem. Recent developments in environmental regulation, coal mining methodology, and treatment of effluent system from mining operation have greatly changed the impact of mining on environment and ecosystem. Hydrological characteristics could be affected by the construction of flood protection levees, overburden dumps, noise protection bunds and loss of water catchment areas diversion of watercourses, offsite discharge of excess treated “dirty” water from the mine site. Changes to the physio-chemical environment of water bodies may have impacts on downstream aquatic flora, fauna, and fisheries.

The soil around the coal mine area is under the Noadda and Amnura soil association and this association maintain the soil quality of the studied area. The soil is predominantly clay-to-clay loam underlain by mainly clay minerals. According to the soil resources guideline of Parbatipur Thana, the cultivable lands of the studied area have been classified as high land to medium high land. In the monsoon period, water remains 2 to 3 months in the medium high land and depth of water does not exceed more than 90 cm. Because of that reason the local farmers are practicing double and triple crops combination pattern in and around the mine area. Occasionally mine disposal water are used for irrigation purposes but according to the soil test (table 6), it has been proved that huge amount of coal slurry were produced from the mine discharged water that decreasing the fertility of soils gradually.

Fig 11: Mine disposal water used for irrigation

According to the Bangladesh population census report in 2011, about 72% of total population largely depends on agriculture. Acceding to the climatological report of Barapukuria (2008), coal mine is affecting the local climate like precipitation, the regular annual variation of monsoon season, and other meteorological conditions. For instance, there is frequent flooding in the rainy season and a completely opposite condition in the dry season has been observed. This may gradually degrade the quality of soil and also the quality of crops and vegetation.

Some stakeholders also complained that the fertility of the land is running out, as they are not getting reasonable amount of crops even after using sufficient fertilizers. Because of coal slurry, the farmers are using more fertilizers than before to rich the target but they are unable to grow more than one crop round the year. Most of the farmers change their occupation because of this unproductive soil. As a whole per capita production, economy is decreasing day by day.

4. REMEDIATION

From the above discussion, it has been cited that the soil as well as the environment in and around Barapukuria is getting polluted thoroughly. However Bangladesh is a power hubbing country, due to that coal production cannot be stopped rather it should have to be continued by minimizing the soil and water pollution. As mine waste water is responsible for soil pollution thus this paper proposed few methods to reduce the soil pollution and also to stop spreading acid mine water around.

Phytoremediation is one of the suitable methods taken to get rid of this problem. In this method some specific plants are used to destroy soil contaminants. However, land-farming (using bulking agents and nutrients), biosparging (using microorganisms) techniques are also suitable. But in perspective of Bangladesh, other remediation options are not suitable. Some buffering agents (CO_2& HCO_3^-) and some chemicals (lime, fertilizers) are also used to neutralize the acidic nature of water (AMD) as well the soil. Finally authors expected a suitable effluent system of mine drainage as mine waste water of very lesser proportion is used in cultivation.

5. CONCLUSION

Huge amount of coal, produced from Barapukuria coal mine, takes the position of Bangladesh one step forward in its development. Lacking of proper treatment plant of Barapukuria, mine waste water spread out thoroughly in adjacent area of mine that degrade the soil as well environment. Approximately 2/3 of people of north-western part of Bangladesh are highly dependent on agriculture for their livelihood thus it is essential to reduce pollution of soil. Using some buffering agents (CO_2& HCO_3^-), acidic water in and around Barapukuria mine can be neutralized. Additionally to improve the soil condition, authors suggest some suitable techniques such as Phytoremediation, land-farming, biosparging(anyone) are to beapplied.

6. REFERENCE

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