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Impact of Coal Mine Waste Discharge on Water Quality of River Damodar with Special Reference to Zinc as Contaminant

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Abstract— Almighty provided us pure water and air for all creatures on this earth, because these are essential for sustaining life. With the rapid increase in population, developmental works and industries, the environment is bound to get polluted. The increase in population has resulted in unplanned habitations giving rise to cuttings of forests, extensive mining, and waste water discharge without any treatment into the rivers / streams. Studies have shown that one of the causes of heavy metal pollution is activity like mining. The most toxic among the trace metals are heavy metals. These have great affinity for sulphur and attack the S-H bond in enzymes resulting in decreased efficiency of the later. Protein and amino acids may also be attacked by heavy metal ions. Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag) chromium (Cr), copper (Cu) iron (Fe). The present study was undertaken to find out the extent of heavy metal pollution in water of river Damodar due to coal mining. Coal has significant quantities of impurities in the form of ash. Washing – also known as coal beneficiation it is a method to reduce these impurities. A typical washing process starts with the crushing of coal to reduce it to a suitable size when water is mixed with impure coal a dense liquid is formed due mixing of water and magnetite the clean coal floats on this liquid while impurities sink. This water from washeries along with impurities forms slurry and is contaminating river Damodar. Water pollution by heavy metals is very prominent in areas of mining and old mine. These metals are leached out and in sloppy areas, are carried along with slurry to river. This slurry is also known as coal sludge. Coal sludge also contains many heavy metals. Small amounts of heavy metals can be necessary for health, but too much may cause acute or chronic toxicity (poisoning). Many of the heavy metals released in the mining and burning of coal are environmentally and biologically toxic elements, such as lead, mercury, nickel, tin, cadmium, antimony, and arsenic, Zinc Chromium as well as radio isotopes of thorium and strontium. During the present study author tried to find out concentration of Zinc, Nickel, and chromium present in coal sludge/ slurry. Samples were collected and analyzed in laboratory.

Keywords— Mining, Pollution, Coal Slurry, Beneficiation, Zinc, Toxicity, Dithizone

I. INTRODUCTION

Water-pollution problems caused by coal mining primarily includes acid mine drainage and metal contamination. When coal and rocks that are unearthed during mining get mixed with water, the process leads to acid mine drainage. Acid mine drainage (AMD) is severe pollution hazard that contaminates surrounding soil, groundwater, and surface water. Although many chemical processes leads to acid mine drainage the primary sources for acid generation is oxidation of sulfide minerals, such as pyrite (iron sulfide), which decompose in air and water. Many of these sulfide minerals originate from waste rock removed from the mine. Infiltration of water through pyrite-laden rock in the presence of air renders water acidic, often reaching pH level of two or three. The chemistry of oxidation of pyrites is shown by the following equation.

$$2FeS_2(s) + 7O_2(g) + 2H_2O(l) = 2Fe^{2+}(aq) + 4SO_4^{2-}(aq) + 4H^+(aq)$$

The poisoning effects of heavy metals are due to their interference with the normal body biochemistry in the normal metabolic processes. When ingested, in the acid medium of the stomach, they are converted to their stable oxidation states Zn^{2+}, Pb^{2+}, Cd^{2+}, As^{2+}, As^{3+}, Hg^{2+} and Ni^{2+} and combine with the body's biomolecules such as proteins and enzymes to form strong and stable chemical bonds.

The present study was undertaken to find out the extent of pollution caused in river Damodar in Dhanbad, due to coal mining waste discharge. Coal has significant quantities of impurities in the form of ash. To remove the impurities and to increase the calorific value of coal washing is done. The process is also known as coal beneficiation. A typical washing process starts with the crushing of coal to reduce it to a suitable size, when water is mixed with impure coal a dense liquid is formed due mixing of water and magnetite. The clean coal floats on this liquid while impurities sink. The washing process generates huge amount of waste water which is known as coal sludge or coal slurry. This slurry goes into a tank called thickeners where slurry gets concentrated from here slurry is released into sedimentation pond where the impurities settle down clear water is again pumped back to washeries for reuse in washing. It was found that in real practice recycling and reuse of water is hardly done. In most of the washeries slurry is directly released into the river. During the present study a concentration of Zinc was determined in different samples of river water collected at different time. pH was also noted for each sample. Samples were collected at the site where slurry is released into river and analyzed in laboratory. Zinc has been reported to cause the same signs of illness as does lead, and can easily be mistakenly diagnosed as lead poisoning (McCluggage, 1991). Zinc is considered to be relatively non-toxic, especially if taken orally. However, excess amount can cause system dysfunctions that result in impairment of growth and reproduction (INECAR, 2000; Nolan, 2003). The clinical signs of zinc toxicosis have been reported as vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane),liver failure, kidney failure and anemia (Fosmire, 1990).The safe concentration of zinc as recommended by WHO is 5 mg/l. Concentration of zinc above 30 mg/l give water a milky appearance and causes formation of greasy film on boiling. Presence of zinc in surface water is particularly toxic to fish and other aquatic organisms. It has been reported that concentration of zinc in soft water ranging from 0.1 – 1.0 mg/l is lethal to fishes. Zinc also has toxic effect towards protozoa and bacteria, presence of zinc causes fall in BOD Zinc is determined by the method that uses the principle that zinc reacts with dithizone.(biphenyl thio carbazone) to form a coordinate compound which when extracted into carbon tetra chloride is red in color is measured spectrophotometrically at 535 nm using a Jasco V-530 UV –Visible spectrophotometer with matched 10 mm quartz cuvetts. pH was recorded using digital pH meter.

II. MATERIAL AND METHOD

During the present study pH and concentration of zinc present in water sample was determined. The Dithizone method was used for the analysis of zinc. Method is based on principle that when Zinc reacts with dithizone (diphenyl thio carbazone) it forms a coordinate compound, which when extracted into carbon tetra chloride is red in color and is used to measure the zinc content.

About 20 metals react with dithizone to form colored complexes. Among them, copper, cobalt, cadmium, lead, nickel and tin are important. If they are present only in small quantities as in case of non-polluted potable water these interferences can be overcome by adjusting the pH of the solution to 4.0-5.5 and by the addition of sufficient amount of sodium thio sulphate. In case of polluted water where interfering ions are present in large quantities dithizone method using bis-2-hydroxy ethyl dithio carbamate was employed. Another important factor in the determination of zinc is the purity of reagents and glass wares. The reagents should be free from zinc. Since glass wares contribute zinc they must thoroughly cleansed with sodium citrate solution before use. Dithizone and zinc dithizonate are readily decomposable in strong light therefore experiments were conducted in subdued light.

III. EXPERIMENTAL

Determination of concentration of Zinc

1. An appropriate volumes of zinc working solution was taken out in to a series of 125 ml. separating funnels to cover the range from 0.40µg of zinc, the volume was adjusted to 20 ml. a separating funnel containing none is also included as the blank.
2. An aliquot of the acid digested sample containing 10-40µg Zn was taken in a separating funnel and the volume was adjusted up to 20 ml.
3. Two drops of methyl red indicator and 2.0 ml. sodium citrate solution was added to the blank, standards and sample. When indicator was not yellow at this point, conc. ammonia solution was added drop wise until the indicator just turns yellow. After this 1 ml potassium cyanide solution was added and conc. acetic acid was also added drop by drop until the solution becomes neutral peach in colour
4. Five ml. CCl_4 was then added in to the separating funnel and the methyl red and was extracted. Yellow CCl_4 layer was discarded.
5. One ml.bis (2-hydroxyethyl) dithiocarbamate solution was added to 10 ml. working dithizone solution. CCl_4 layer was drawn off in to another separating funnel. The aqueous solution in the first separating funnel was extracted with 5 ml. portions of working dithizone solution until the last extract remains green. All the CCl_4 extracts were combined
6. To the combined CCl_4 extracts in the separating funnel 10 ml. sodium sulphide solution was added. After shaking well the aqueous layer was discarded. The CCl_4 layer was washed with further 10 ml. portions of sodium sulphides solution until the unreacted dithizone has completely been removed as shown by colour of the aqueous layer either colourless or very pale yellow.
7. The CCl_4 layer was drawn off into a 50 ml. volumetric flask after removing the water adhering to the stem of the funnel by means of cotton swab. Make up was done up to the mark with CCl_4.
8. Absorbance was recorded for the blank, standard and sample at 535 nm calibration curve was plotted to find out the milligram equivalent of Zinc to the optical density.

IV. SURVEY OF LITERATURE

Partha Das Sharma has published many paper and books which address to the problem of pollution caused by coal mining.

Dietz, J. M., and D. M. Stidinger. And coworkers worked to evaluate the acidic mine drainage and abatement in an anaerobic Sub-Surface Flow Wetland Environment. Earle. J, and T. Callaghan. 1998. and coworkers studied Impacts of acid mine drainage on aquatic life.

Belmer et.al. studied the impact of coal mine on water quality and aquatic ecosystem. Harrisburg. Hedin, R.

S., R. W. Narin, and R. L. P. Kleinmann. and coworkers worked on Passive Treatment of Coal Mine Drainage. Dave Johnston Hugh Potter Ceri Jones Stuart Rolley Ian Watson Jim Pritchard worked on abandoned mine and the water environment. Amit Kumar of Norman B. Keevil Institute of Mining Engineering - University of British Columbia studied acid mine drainage and recommended remedial measures.

V. RESULTS AND DISCUSSION

Table: 1

S.NO	Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
1	Zinc in mg/l	18	52	46	22	62
2	pH	6	5.8	4.8	4.6	4.9

The Table above shows the result of the study

From the above table it is evident that during the study concentration of zinc was found to be quit higher than the safe limit. If we talk about pH it was also highly towards acidic side causing pollution of water of river Damodar to a considerable extant. The pollution caused by mining waste over burdens fly ash, oil, toxic metals and coal dust into river. It was observed during study that improper maintenance of washeries add to severity of pollution. At most of the places pumps which drain out clear water from sedimentation tank were not in working order. Sedimentation tank were not cleared on regular basis. Dry slurry was not removed regularly which caused overflow of sedimentation tank during rain and on the days when washing was done in full swing. This over flown water carries pollutants to river water and to nearby land and field. Proper disposal of dry slurry was also an unsolved issue. Therefore It is the need of the hour to address to this alarming situation to protect river Damodar.

VI Graphical Representation Of Results Of The Study

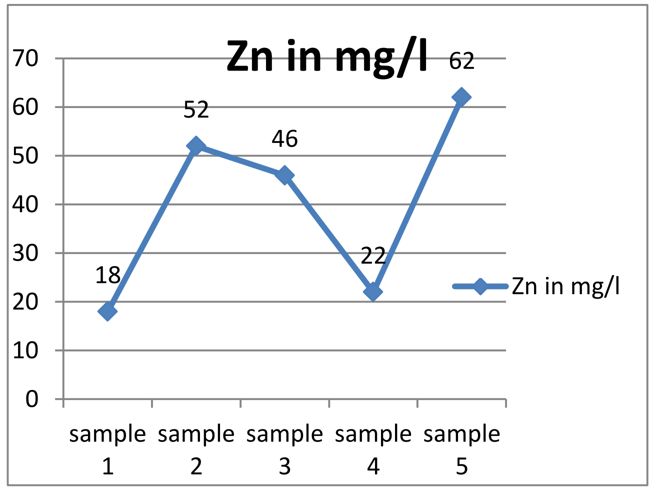

Fig.1. concentration of Zinc in mg/l in different sample of water

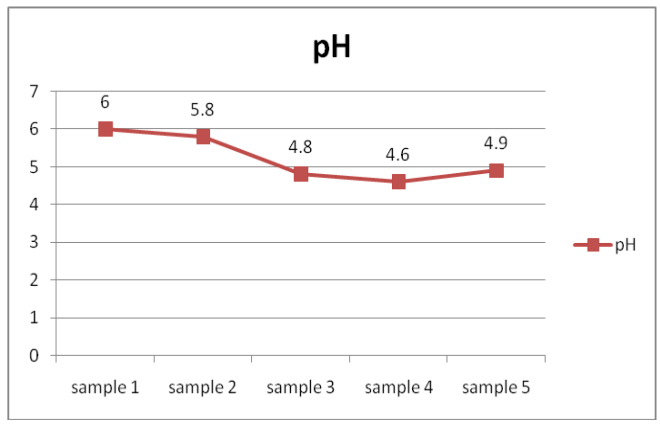

Fig.2. pH of different sample of water

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