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# Effect of Acid Mine Drainage on Quality Deterioration of Aquatic Ecosystem and Behavioural Changes of Aquatic Organisms

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## ABSTRACT

Physico chemical characteristics of various aquatic ecosystems have been altered by large scale environmental degradation due to extensive deforestation and coal mining in the area. The primary cause of degradation of water quality and the declining trend of biodiversity in the water bodies of the mining area is mainly due to the Acid Mine Drainage (AMD) originating from coal mines. Simsang river of Garo hills that constitute an important habitat for coldwater fisheries has become one of the major victim of this. Low pH ,high conductivity, high concentration of sulphates, iron and toxic heavy metals , low DO are some of the physico-chemical and biological parameters which characterize the degradation of water quality. In the present study heavy metals like Fe, Cd, Pb, Ni, were detected in the AMD mixed water above permissible limits. Out of this Fe, Pb, Cd were present in high amount . Different behavioural changes including hyperactivity, changes in opercular movement rate, irregular swimming activity, jerking movements, loss in equilibrium , secretion of excessive mucus were reported during present study.

**Keywords :** AMD, Heavy Metals, Behaviour, Ecosystem.

## I. INTRODUCTION

Aquatic ecosystems have been threatened by large scale environmental degradation due to extensive deforestation and coal mining in the nearby area. Due to coal mining, the area has faced certain never ending problems like soil erosion, scarcity of water, pollution of air, water and soil, reduced soil fertility and loss of biodiversity. The primary cause of degradation of water quality and the declining trend of biodiversity in the water bodies of the mining area is mainly due to the Acid Mine Drainage (AMD) originating from coal mines. As a result, water from the region has become highly acidic and rich in heavy metal concentration. Generally, the acidic discharge from active or abandoned mines are termed as Acid Mine Drainage . The aquatic ecosystem have been highly contaminated with different types of heavy metals that may come in contact with the water body either from natural or from manmade source such as different coal mine industries. Pollution of the water is indicated by the colour of the water which become brownish to reddish orange. Low pH ,high conductivity, high concentration of sulphates, iron and toxic heavy metals , low DO are some of the physico-chemical and biological parameters which characterize the degradation of water quality. Heavy metals are essential for maintaining body metabolism at their optimal range but if their concentration in body increases beyond the required concentrations, it can lead to various abnormalities. Heavy metals are regarded as serious source of pollutants because of their environmental persistence and bioaccumulation and biomagnifications in food chain. AMD is produced by a series of complex geochemical and microbial reactions that occur when water comes in contact with pyrite found in coal and exposed rocks of overburden. Some or all of this iron can precipitate to cause turbidity of water and sedimentation at the bottom of streams. The acid runoff or AMD creates problem further by dissolving heavy metals such as aluminium, copper, lead, mercury etc. found in rocks and soil. As a result, the AMD contaminated surface water is not only acidic but also rich in different metals (Johnson & Bradshaw, 1978). Meghalaya possess rich deposits of various minerals including coal. The coal deposits in the state occur along the southern fringe of the Shillong plateau distributed across Khasi Hills, Garo Hills and Jaintia Hills. Simsang river of Garo hills that constitute an important habitat for

coldwater fisheries has witnessed severe damage due to coal mining practices coupled with climate Change (Sarma *et al*. 2009).

## II. METHODS AND MATERIAL

To assess the toxicity of AMD on behavioural changes ,a living model was selected for the present study. The biological model was selected from icthyofauna which represents the major aquatic fauna of riverine and *beel* water. For the present investigation, *Heteropneustes fossilis* (locally known as "*Singhi fish*") was selected, since this fish is easily available throughout the year and has a high percentage of survival in the laboratory condition. Water collection was done from Simsang River (Garo hills) from the site where water is contaminated with AMD effluents of coal mine from the coal mine of Meghalaya. Healthy fishes of length 15-18 cm were collected from nearby local market irrespective of sex and kept in glass aquarium for 10 days for acclimatization. The test fishes were treated with 5% $KMnO_4$ solution for five minutes to clear any dermal infection. During this period fishes were fed with commercial food to avoid the effect of starvation.

Water quality viz. pH, conductivity, temperature, total dissolved solid, alkalinity as $CaCO_3$ , DO, free $CO_2$ and hardness were also determined following the protocols outlined in APHA (2005). After 96 hours of observation $LC_{50}$ value was obtained as 28.5%. The heavy metals, As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Fe, and Zn were measured in water sample with atomic absorption spectrometry (Varian SpectrAA-220 AAS) using air-acetylene flame.

**Table 1:** Analytical conditions for atomic absorption analysis (Varian SpectrAA 220)

| ***Elements*** | ***Wave length (nm)*** | ***Slit width (nm)*** | ***Optimum working range (μg/ml)*** | ***HC lamp current (mA)*** | ***Type of flame*** | ***Fuel gas flow rate (L/min)*** | ***Air flow rate (L/min)*** |
|---|---|---|---|---|---|---|---|
| As | 193.7 | 0.5 | 3.0 – 150.0 | 10 | $C_2H_2$-$N_2O$ | 1 | $N_2O$-3.5 |
| Cd | 228.8 | 0.5 | 0.02 – 3.00 | 4 | Air– $C_2H_2$ | 1 | 3.5 |
| Co | 240.7 | 0.2 | 0.05-15 | 7 | Air– $C_2H_2$ | 1 | 3.5 |
| Cu | 324.7 | 0.5 | 0.03 – 10 | 4 | Air– $C_2H_2$ | 1 | 3.5 |
| Fe | 248.3 | 0.2 | 0.06 – 15 | 5 | Air– $C_2H_2$ | 1 | 3.5 |
| Mn | 279.5 | 0.2 | 0.02 – 5.00 | 5 | Air– $C_2H_2$ | 1 | 3.5 |
| Ni | 232.0 | 0.2 | 0.1 – 20.00 | 4 | Air– $C_2H_2$ | 1 | 3.5 |
| Pb | 217.0 | 1.0 | 0.1 – 30.00 | 5 | Air– $C_2H_2$ | 1 | 3.5 |
| Zn | 213.9 | 1.0 | 0.01 – 2 | 5 | Air– $C_2H_2$ | 1 | 3.5 |

## III. RESULT AND DISCUSSION

**Table 2:** Physico chemical characteristics of normall and AMD mixed water.

| **Parameters** | **AMD mixed water** | **Tap water** |
|---|---|---|
| Ph | 2.21 | 7.2 |
| Salinity (ppt) | 2.37 | 0.12 |
| Conductivity(mhos/cm) | 245 | 152 |
| TDS(ppm) | 329 | 83.4 |
| DO(mg/L | 3.30 | 8.2 |
| Alkalinity(mg/L) | 10 | 120 |
| Free $CO_2$ (mg/L) | 22 | 4.5 |

**Table 3:** Content of heavy metal in AMD water sample and permissible limit.

| **Heavy metals** | **AMD mixed water(mg/ml)** | **Permissible limit (mg/ml) (WHO2006)** |
|---|---|---|
| **Fe** | **16.970** | 1-3 |
| Cu | BDL | 2 |
| Mn | 0.557 | 0.2-10(FAO 1985) |
| **Ni** | **0.427** | 0.07 |
| **Cd** | **0.081** | 0.003 |
| **Pb** | **0.490** | 0.01 |
| As | 0.000052 | 0.01 |
| **Ca** | **6.51** | 25 |
| **Mg** | **3.41** | 30 |
| Zn | 2.202 | 3 |

*Behavioural changes of model organisms* **:** *H. fossilis* which were kept in $1/5^{th}$ of $LC_{50}$ value of AMD showed hyperactivity, changes in opercular movement rate, irregular swimming activity, jerking movements, loss in equilibrium etc. Excessive mucus was secreted by the fishes to protect it from toxic surroundings. These behavioural changes are mainly due to the changes in physico chemical nature of the water and toxic nature of the heavy metals which caused severe disturbances in the fish physiology .

*Discussion* : The AMD mixed water is highly acidic having pH 2.21 and alkalinity is very low10mg/L. The optimal pH for fish ranges from 6.5 to 8.5. Fluctuation of pH indicates low buffering capacity of the water body. This condition may be due to low concentration of alkaline compounds or bases such as carbonate, bicarbonate and hydroxyl ions which are reflected in the low alkalinity of the water observed in the present study. Acidic pH is said to favour absorption and deposition of certain elemental residues in the tissue. Acid stress on fish depress the immune system, inhibits development, increased malformed embryos and disrupt the endocrine control over reproduction (Ikuta et al.,1999). Dissolved oxygen is another parameter considered to be very essential in the aquatic environment. Low concentration of DO (3.3 mg/L) recorded is likely to cause stress on fish due to low energy production, since oxygen is needed for ATP synthesis in the mitochondria. The optimal level of DO for better growth and performance of fishes ranges between 7 and 9mg/L. The recorded free $CO_2$ (22 mg/L) may also contribute to stress on fish by reducing the pH when the concentration of dissolved oxygen is low. In water of low $O_2$ and high $CO_2$ where gaseous exchange at the respiratory surface is limited, the fish increases their ventilation rate, becomes restless, loses equilibrium, and may die. Low alkalinity (10mg/L) of the water indicates susceptibility of the water to fluctuations in pH from acid contamination. The desirable range for alkalinity for fish is 50-150 mg/L as $CaCo_3$ (Murphy, 2007). In former studies it is reported that at high alkalinity, heavy metals , particularly lead and cadmium precipitate by forming complexes with bicarbonates and carbonates thereby reducing their toxicity. Thus, low alkalinity detected in the present study may enhance toxicity in fish due to fluctuation in pH. More significantly, low alkalinity may also increase toxicity due to available heavy metals such as lead and cadmium which are detected in the water sample in high concentration. Heavy metals are the potential pollutants whose occurrence and concentration cause degradation in the quality of the aquatic environment. Cd is a non-essential, non-biodegradable heavy metal with no known biological function. Pb and Cd may cause oxidative stress on fish by generating the reactive oxygen species or free radicals which are capable of interacting with nuclear protein and DNA .Lead toxicity is also responsible for changes in blood parameters with severe damage to the erythrocyte and leucocytes. Lead causes early mortality of mature RBC and inhibition of haemoglobin formation through inhibition of erythrocyte d Amino Levulinic Dehydratase resulting in anaemia at high exposure of metal( Johansson-Sjobeck,M.L.& Larsson ,A,1979). In the present study heavy metals like Fe, Cd, Pb, Ni, were detected in the AMD mixed water above permissible limits. Out of this Fe, Pb, Cd were present in high amount.

## IV. CONCLUSION

There is a need for further dose-related studies on the effects of Acid Mine drainage on aquatic ecosystems. There is also a need to establish the ability of fish to adapt to chronic exposure to Acid Mine Drainage of coal mining. Comet assay as well as ladder test are also very much important to evaluate genotoxic affect on aquatic organisms,

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## VI. REFERENCES


[1] Acid Mine Drainage and Effects on Fish Health and Ecology: A Review(2008) ;U.S. Fish and Wildlife Service, Anchorage Fish and Wildlife Field Office

[2] APHA(1992).Standard methods for analysis of water and waste water.18th Ed. American Public Health Association, Inc., Washington D C..

[3] Earle, J. and Callaghan .T. Impact of Mine Drainage on Aquatic life,Water uses and Manmade structures.

[4] Goel, K.A. & Sharma ,S.D.(1987).Some haematological characteristics of Clarias batrachus under metallic stress of arsenic.Comp.Physiol.Ecol.12:63-66..

[5] Impact of Coal Mine Waste Water Discharge on Surroundings With Reference to Heavy Metals,(2011) . Central pollution control board.

[6] J. Durlach , M. Bara, A. Guiet-Bara , Magnesium level in drinking water: its importance in cardiovascular risk, Magnesium online library.

[7] Johansson-Sjobeck, M. L & Larsson, A. (1979). Effects of inorganic lead on delta aminolevulinic acid dehydrataseactivity and hematological variables in the rainbow trout, Salmo gairdneri. Arch. Environ .Contam.Toxicol.8:419-431.

[8] Kathleen M. Raley – Susman , Like a canary in the coal mine :Behavioural change as an early warning sign of neurotoxicological Damage.

[9] Madhyastha,M.N. and Nayak , R. ,Effect of a combination of pollutants on the fish Rasbora daniconius, The biosphere: Problem and solutions, edited by T.N. Veziroglu , Elsevier Science Publishers B.V.,Amsterdam,1984-Printed in The Netherlands.

[10] Mustafa,S. and Murad, A.(1984) Survival , Behaviour Response and Haematological Profile Of Catfish H. fossilis exposed to DDT. ,Japanese Journal Of Icthylogy,31.No1.

[11] Sarma ,D., Sarma ,D. , Das ,J., Rabha ,M ., Dutta ,A . and Mahanta , P.C.(2009).Potential impact of climate change ,coalmining on cold water fish and fisheries of Simsang River ,Garohills.

[12] Sarma,D. and Dutta,A.(2013) Acute Toxicity and Behavioural Changes in Channa punctatus Exposed to Rogor (An organophosphate),Nature Environment Pollution Technology 12(4):641-644.

[13] Siddiqui, A. A. and Chang, S.(2014). Cadmium chloride intoxication and evaluation of protein changes in Clarius batrachus. International Journal of Current Microbiology and Applied Science,3(1).

[14] Srivastava ,G. and Srivastava, A. K., (2001).Toxicological effects of selenium on the haematological parameters of a freshwater catfish, H. fossilis (Bloch)Indian J. Sci . Res .2(3):109-114.

[15] WHO (World Health Organization), (2005). Guidelines for drinking water. WHO, Geneva.