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Heavy Metal Pollution of River Ganga Water

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Abstract: The Ganga, is one of the most sacred and worshipped river of India, is regarded as the cradle of Indian civilization. The major objectives of the present study were to investigate heavy metal's concentration in water and sediments of the River Ganga along the different locations of patna city viz gai ghat, kali ghat, naujar ghat. Water and sediments collected from four locations were analysed for Iron (Fe), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Manganese (Mn) with Atomic Absorption Spectrophotometer. Contamination Factor (CF), Contamination Degree (CD), Pollution Load Index (PLI) were used to assess the degree of accumulation of heavy metals in sediments. Anthropogenic activities have generated important transformations in aquatic environments during the last few decades. Human civilization has put serious questions to the safe use of river water for drinking and other purposes. The river Ganga water pollution due to heavy metals is one of the major concerns in most of the metropolitan cities of developing countries. Heavy metal concentration in sediments of Ganga River was studied sites situated at Patna.
Keywords: Suspended, Drinking water, Pollution, Heavy metals, water, sediments, Contaminant, Ganga

I. INTRODUCTION

The Ganga River is one of the most utilized rivers in the india. Due to abundant availability of water throughout the year, it has played an important role in the development of Indian civilization and economy. Increased urbanization and industrialization in the basin, has resulted in polluting the river, since the river has been a preferred waste disposal site for industrial and domestic effluents. The measurements of dissolved pollutants in the water are not conclusive due to water discharge fluctuations and low residence time of the pollutants. River ganga sediments act as both source and sink for heavy metals and are important sources for the assessment of man-made contamination in rivers (Förstner and Wittmann 1983). During the past two decades a number of studies have been reported, which dealt with heavy metals in the sediments of the Ganga River.

A. Sample location

Twenty four samples were taken along the River ganga from two sections or sites of the river (A and B). Site A describes samples obtained from the lower sections of the river, from patna represent, respectively, samples taken from study site A and B.Sampling protocols and sampling site selection followed that described. The sampling sites were also selected based on accessibility and the proximity of the sites to the various towns along the course of the river. Water and sediment samples were obtained at each sampling location along the river Ganga. Generally, the nature of the Ganga water in both study areas was very turbid, light-brown in colour, and shows indications of highly suspended sediments.

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II. GANGA RIVER SITE PICTURE IN PATNA

A. Sampling and Preservation

All the sampling points, the water samples were collected in the direction opposite to the flow of the river. This was done to prevent/minimise the direct release of other contaminants from the human body that might affect the sampling accuracy. At each sampling site, the water was filtered through 0.45 µm micro-glass fibre filter membrane with a hand held pump and Nalgene polysulphone filter unit. An approximately quantity of 250 ml water was filtered into 60 ml and 125 ml black polyethylene containers. as possible, air bubbles were secluded in each sampling bottle. 4 drops of 50% concentrated ultrapure HNO_3 acid were added to the 125 ml water samples which were intended for cation (metal) analysis whilst the 60 ml water sampled bottles intended for anion analysis were not acidified. These samples were later kept in temperature controlled and monitored iced-chest at 3°C on the field but later stored in a refrigeration system after the field work and the temperature set and monitored at 3°C before transportation to the laboratory for analyses. The sediment samples were obtained as much as possible from the exact vertical position of the water sampling points. However, for sampling locations of difficult accessibility, sediment samples were obtained close to where the water samples were collected. The sampled river ganga sediments were air dried under a less windy shady environment and carefully repacked into paper bags for transportation to the laboratory for analyses. All the collected samples were packed into insulated thermal bags and transported to the laboratory Mirza Galib collage, Magadh University, Gaya. Upon arrival at the laboratory, the sediment samples were quickly oven dried at 60°C for approximately 70 hrs before cooling to normal room temperature whilst the water and filter cake samples stored in the refrigerator at 3°C.

B. Analytical Technique

Samples were analysed for metal concentrations of Cr, Fe, Ni, Zn, As, Cd, Hg and Pb using the Perkin-Elmer AA analyst 400 Atomic Absorption Spectrophotometer (AAS), and the Agilent 7700 Inductively Coupled Plasma – Mass Spectrometer (ICP-MS).

C. Atomic Absorption Spectrometer

The AAS is a spectroanalytical procedure for the quantitative determination of chemical elements employing the absorption of optical radiation (light) by free atoms in the gaseous state. It is a well-established technique for metal determination, being the instrumental method of choice for aqueous samples in laboratories. The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. It is based on the phenomenon that the atom in the ground state absorbs the light of wavelengths that are characteristic to each element when light is passed through the atoms in the vapour state. Because this absorption of light depends on the concentration of atoms in the vapour, the concentration of the target element in the water sample is determined from the measured absorbance.

D. Inductive Coupled Plasma – Mass Spectrometer

The Agilent 7700 ICP-MS was used in analysing the major and trace elements content of the samples. The details and mode of operation has been reported. Generally, the concentrations of the elements in the sample are calculated by taking the peak area for a single isotope of the element of interest, the precision of the ICP-MS is between 2 and 5% relative standard deviation (RSD) while accuracy is better than 4.5% absolute. It also provides near determination of most elements in the periodic table at levels down to 10 pg/ml.

III. RESULT AND DISCUSSIONS

A. Heavy Metal Concentrations of the River

The concentrations of the heavy metals in all the samples and its considered tributaries were measured as dissolved pollutants thus, elements passing through the 0.45 µm filter paper, suspended sediments. (elements in the cake on the filter paper after filtration), and easily available or labile pollutants (elements present in suspended materials settled to the river bed).

B. Dissolved Metal Concentration

The dissolved concentrations of heavy metals (Cr, Fe, Ni, Zn, As, Cd, Hg and Pb) in water samples taken from the 24 sites along the River Ganga and the WHO standards for the various metals in fresh natural waters. Comparatively, the measured dissolved concentrations of heavy metals from all the sampling sites were below the WHO standards except for Fe. All the measured dissolved Fe concentrations along the Birim River for Study Area A were all above the World Health Organisation (WHO) standard of 0.30 mgL^{-1}.

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Fe concentrations along the River Ganga. Fe indicating that mining activities through exposure of rocks to weathering and leaching contributes massively to heavy metal pollutions in the River Ganga. The variations in the levels of heavy metals concentrations from site A and B, may explain the degree of pollution in the two sites. It also shows that, mining activities disseminated along Site A, are more intense compared to Site B. For example, high Fe concentrations recorded for Site A compared to Site B suggest that, Site A, is more polluted in Fe than Site B. The high Fe concentration observed. The high amounts of iron and other toxic chemicals such as manganese. Rock analysis conducted showed that Fe_2O_3 composition is approximately 2.8%, serving primarily as the major source for Fe in fresh waters. Other sources for the high Fe concentration observed may be related to the continual discharging of mining waste generated from Small Scale mining activities. Iron is an essential element in the human nutrition. However, the toxicity of iron to the human body is Governed by the absorption rate. Thus, the more one takes in Fe, the more one is at risk. The estimates of the minimum daily requirement for iron depend on age, sex, physiological status, and iron bioavailability, and ranges from about 10 to 50 mg/day. The ingestion of high amounts of Fe in drinking water can pose health problems such as anorexia, oligura, diarrhoea, hypothermia, metabolic acidosis and in some cases death. Hepatoma, the primary cancer of the liver has become the most common death among patients with hemochromatosis.

C. Sediment Metal Concentration

Generally, suspended sediment adsorbed pollutants from flowing water in rivers and deposits onto the bed. The accumulation of pollutants in the river Ganga bed sediment however, can affect the bio-community through food chain for a long period of time. As a result, assessment of the river sediments through weak digestion for all the sediment samples were conducted to have an idea on the labile fraction of metal contaminants available in river ganga sediments that could easily be released into the aquatic environment..The high level of metal concentration in the river Ganga sediment relative to levels in the water as dissolved and suspended is expected since sediments have been described as a sink or reservoir for pollutants in water. Again, for the sediment samples, Fe recorded highest metal concentration at all sampled points, which reaffirm the hypothesis that the river Ganga is heavily polluted in Fe. Moreover, the metal concentration levels for the other heavy metals (Hg, Pb, As, Zn, Ni, Fe, and Cr) for both sites A and B were relatively high. Interestingly, Cd was not found in the sediment samples. This may be as a result of the digestion method used and/or the absence of precipitates or complexes of Cd in the sediments of the river. These results suggest that consumption of the polluted water by animals or human beings could be hazardous to their health. For example, once mercury is in the water, it is easily adsorbed to the suspended particulates including micro-organisms which enters into the food chain through the consumption by fishes or sinks into the river sediment before being transported downstream. The larger sediment sinks to the bottom but later re-enters the aquatic system when floodplain materials are reworked by erosion. Similarly, accumulation of As in river Ganga sediment with time can dissolve back into the river, which when ingested can cause multiple internal cancers in the liver, kidney, lung and bladder

D. Pollution Of The River Ganga

The extent of pollution of natural water systems aids in defining the sources of pollution, remediation technique adopted, and areas or locations along the course of the stream or river that needs remediation attention. The extent of pollution for heavy metal load can be estimated by determining the background concentrations of species in the river body and subtracting it from the total measured species concentration at various sampling points along the river course. It also provides idea on the total enrichment caused by natural geochemical processes and other anthropogenic activities. the preferred approach for estimating the background concentrations of a river is to collect samples from the stream or geological formation of interest somewhere near the source, where the water quality has presumably not been altered or disturbed by human activity.

E. Pollution Suspended Particle

The estimated pollution load per suspended mineral fractions in the River Ganga. The anthropogenic release of pollutants from these mining activities and the inter-relationship between the released metals, geology and geological processes of the area have greatly and negatively affected the quality of the river Ganga by introducing much pollutants into the suspension. The accumulation of relatively high concentrations of metals (Fe, Ni, As, Hg, Zn, and Cr) can be related to the mixing of the sediments through anthropogenic dredging, panning and pitting activities in and around the River basin during mining activities. These encourage geochemical processes (including weathering or leaching of rocks surfaces) and other processes such as ion-exchange, adsorption and desorption, dissociation, precipitation, etc.

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Geochemical processes including redox reactions, adsorption, sorption, precipitation, ion-exchange, and methylation of free and organic-metallic metals in rivers cause the deposition of heavy metals to the bottom of such rivers. The main sink of the heavy metals present in the particulate matter of the river increases the pollution load accumulation in the river sediments..The river sediments are easily available to the aquatic system, and hence affect the river quality through major physical, geological and geochemical processes occurring in the river. These processes which include hydrolysis, solubilisation, dissolution, methylation, ion- exchange, complexation etc. enable metal ions to be released from the sediments into the river through prevailing conditions.

IV. CONCLUSION

The study ascertained the concentrations, mobility, and general pollution loads of heavy metals in the River Ganga. The dissolved metal concentrations of the upper and lower sections of the River Ganga are relatively lower than the critical level permitted by WHO standard for natural waters with the exception of Fe which showed relatively higher concentrations along the lower section. Moreover, the dissolved Fe concentrations along the upper sections of the river were relatively lower compare to Fe concentrations in the upper sections of the river. However, filtration of the water before usage for domestic and drinking purposes is highly recommended to eliminate these dissolved metals. Metal concentrations in the suspended mineral fractions at the source of the River Ganga were either absent or low with the exception of Pb and traces of Hg. The exceptional metals measured at the source could be attributed to the geological erosions or organic loading in the suspended particulate matter in the river. The concentrations of metals deposited on the River bed and suspended mineral fractions were very high along both the upper and lower sections of the river Ganga. The pollution load in terms of the relative accumulated concentrations of suspended mineral fractions and labile elements quantified along the considered sections of the River Ganga were very high compared with its background concentrations at the source. These sections of the river in the towns have accumulated relatively high concentrations of metals such as Fe, Mn, Ni, As, Hg, Zn, and Cr. It has been identified that, the major sources of pollutants to the river results from illegal artisanal or small scale mining activities in and along the river basin. The release of Hg from the small scale mining activities into the environment was outrageously high. All the measured Hg were found at places with active mining activities, mostly existing in the suspended phases and the precipitates at the bottom of the river. Due to the organo-complex nature of inorganic mercury, the measured Hg in the river body would heavily Impact its aquatic system (microbes, zooplanktons, fishes, etc.) and hence humans through bioaccumulation of such metals when they enter into the food chain The environment is heavy metal and Hg pollution in the resulting from activities in and around the river Ganga.

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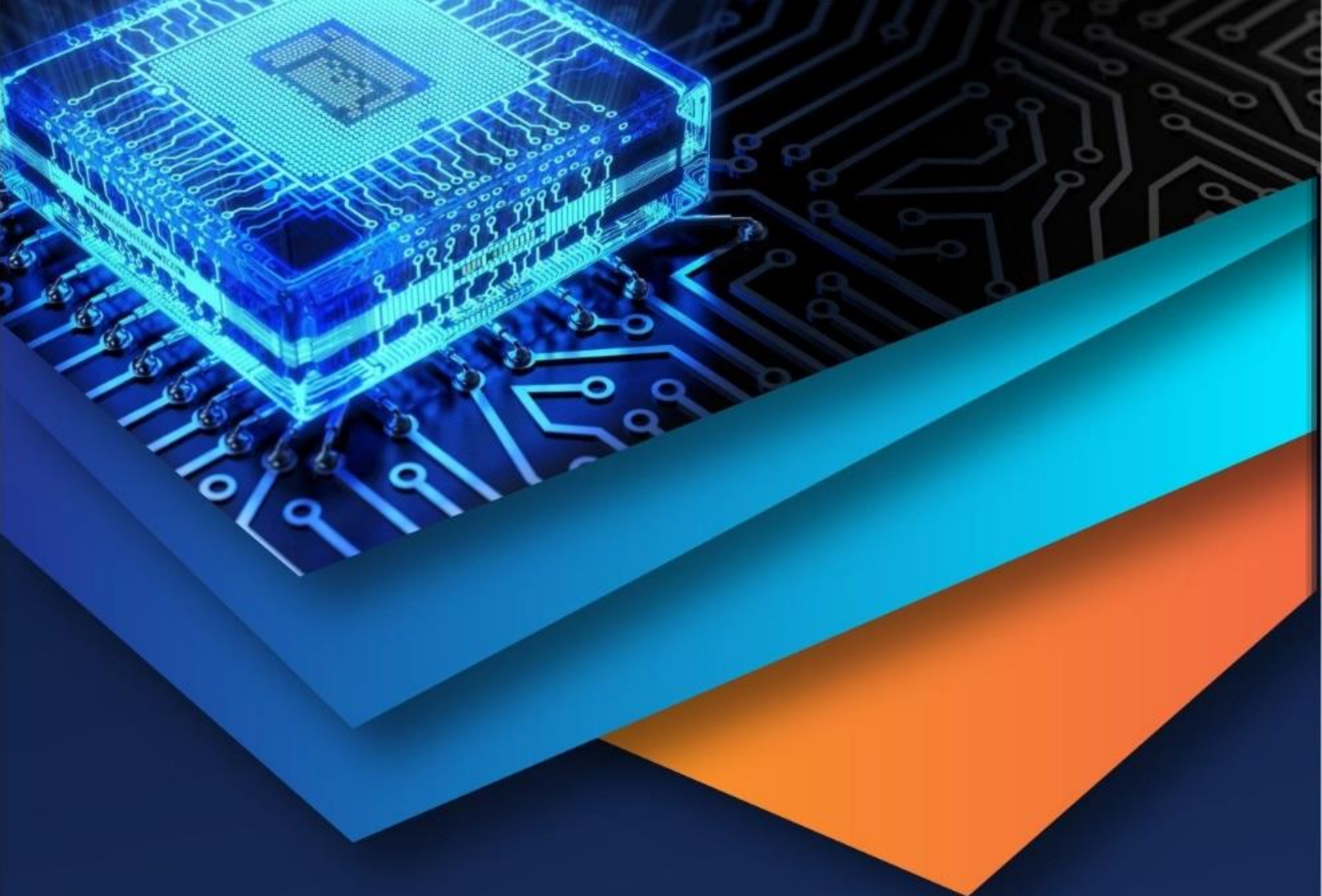

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