International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 11, Issue. 1, April 2024, pp. 2274-2287 **DOI: 10.26540/ijgsr.v11.i1.2024.264**
***Available Online* at www.ijgsr.com**

Research paper

The Physicochemical studies of coal-fly ash in water of Amarkantak thermal power plant Chachai (MP)

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Received: 22/01/2024
Revised: 30/01/2024
Accepted: 10/02/2024

Abstract: Amarkantak Thermal electricity plants utilize bituminous coal as a fuel, which incorporates an excessive amount of ash (as much as 40 %), sulfur (0.2- 06%), and heavy metals such as Hg, Mn, Cu, Pb, Ni, Fe, Cr and Cd in varying percentage. However fly ash generally includes just about 50% silica which together with oxides of Al, Fe, and Ca increases 95 to 99 percent of its contentswhereas Na, Mg, Ti, K, C, and S make up 0.5 - 3.5%. The rest of the ash comprises trace elements. (Davison et al., 1974). The plant disposed of ash combined with warm wastewater at the Sone River and for that reason, it has an unfavorable effect on the river. Consequently, the quality of the water has been altered. Some studies have confirmed that a big quantity of heavy metals, like lead, copper, nickel, silicon,etc were found in the disposal water. Water quality in any ecosystem provides significant information about the resources accessible to support life in that ecosystem. Several physicals, chemical and biological parameters of water indicate the quality of waterbodies that can vary under the toxic effects of pollutants. In the present observation, in water, the concentration of metals such as Pb, Al, Fe, and Cr was found much higher than the permissible limits prescribed by WHO and Indian Standards.

Keywords: Coal Fly Ash, Water, Chemical Composition, Heavy Metals, Amarkantak Thermal Power Plant

Introduction:

Interest in fly ash & metals in recent years has increased in recent years due to increased urbanization and industrialization and also due to increased exposure of living organisms to metal pollutants. Along with technological development, the level of pollution is also increasing day by day. Industrialization is our need but the dilemma is that, as industrialization is increasing, so is the pollution also increasing. Development is the result of the depletion of natural recourses and the production of many products in the form of waste.

It is known that India needs energy for its progress as studied by the Desai in 2008. According to many workers such as Kumar in 2003, Mishra in 2004, and Saravan and

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Sundaramoorthy in 2008, India produced its seventy percent ofelectricity only from coal in thermal power stations whereas remaining from the other sources such as oil, gas, nuclear and hydroelectric. That is why day by day power station demands are increasing in India resulting, in many plants are under construction at present. According to Dutta 2002, the electricity generation in India in 1947 was 1362 MW while in 2002 it increased to about 105000 MW.

As described by the many researchers like Srivastava in 2012, Shyam in 2000, Ratan and others in 2005 and Bhattacharya and Chattopadhyay also in 2005, Power generation and production of fly ash is not the main problem for the people, the problem is related to its disposal and sedimentation in water bodies like river, ponds, sea, Lake etc. When it accumulates in water, it can lead to adverse changes in concerned water bodies or ecosystems. It can be a threat to aquatic organisms especially fish and their food. It can disrupt the food chain of the aquatic ecosystem. Due to anthropogenic activities, the Physical, chemical and biological parameters of water are going to deteriorates day by day.

According to Van Vuren and Rudra in 1999, power plants are the main producer of pollutants which is responsible for the adverse changes in the quality of water and soil. Previous workers have studied that the waste water of power plants contains many pollutants including toxic heavy metals. These toxic heavy metals don't have any biological values these only responsible for the adverse impact on aquatic ecosystem. As was known, coal based thermal power plants produce coal ash and also spread it to the surrounding water bodies and soil. Fly ash being heavy gets deposited at the bottom of water bodies.

Description of the study site:

Amarkantak thermal power plant is placed at Chachai this electricity plant is one of the coal primarily based plants of Madhya Pradesh. The Amarkantak thermal electricity Station is located (23'10' range & 81' 30 longitudes') at the proper pool of the Sone river. This power plant turned into set up in 1962-1965. Chachai Dam is a multipurpose River Valley project on river Sone located inside the Gangas Basin in Madhya Pradesh, at village Chachai in Anuppur district, At a distance of 172km from Katni and 30 km from Shahdol, located at latitude 23-10' N and longitude 81' 30"E. Its catchment location is 25 square miles.

The Sone River originates from Amarkantak and flows upstream near Anuppur to Diyapiper, Ksheer Sagar, and finally reaches Deolond where the multipurpose project Bansagar Dam is constructed not only for irrigation but for pisciculture and drinking also.

This is a fully running thermal electricity plant and the electrical energy from the plant is connected to the regional grid. Here coal is employed because the primary fuel and heating oil are employed because the secondary fuel. The primary source of coal for the plant is from southeastern coal area confined and the primary supply of cooled water is from a dam, that's constructed on Sutna Nala of Sone River, the pond has a general capacity of 700 acre. Mercury control tool isn't used on this plant.

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Image: 1. Showing side view of Chachai Dam

Fly Ash- A brief account:

Coal fly ash is a composite material produced from the ignition of crushed coal in thermal power plants during electricity production (Shrivastava, 2011). It's a fine gray powder. It consists mostly of globular, glassy particles size ranging from 0-10 0 microns, which are produced as a byproduct in coal-fired power plants. Fly ash is the finest form of coal ash. It is carried by exhaust gases from the combustion chamber this is why it's called fly ash. According to Kumar (2003) fly ash is the remains of coal combustion and comprises a wide range of inorganic particles with highsurface area and low density. In India per year fly ash production is about 112 million tonnes (Alam and Akhtar, 2011).

Fly ash is a ferro-aluminosilicate mineral consisting of major elements such as Si, Al, and Fe along with significant amounts of Mg, Ca, P, S and K (Aslam, 1998). Coal fly ash may contain little amount of a number of heavy metals that can cause major health problems in humans as well as aquatic flora and fauna. These are arsenic, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, selenium, thallium and uranium. Some ofthe metals enriched in fly ash are Cd, Ni, Cr, Mn, Fe, Pb, Mg, Al, Si and Zn whereas others found in trace amount. According to Adriano, 1980, micro and macro nutrients present in coal get usually concentrated in the ash that is why sometimes fly ash is used as soil conditioner for enhancing the yield of the crops.

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Image: 2 - Showing Fly ash collected from the study area

The Chachai dam is built on the Sone River. The river is being contaminated because the power plant disposed ash mixed hot waste water on the Sone River and consequently it has an adverse impact onthe river. So the physical and chemical parameters of the river altered.

Materials and Methoda:

To assess of the fly ash and chemical composition of coal fly ash on the Sone River at Chachai dam near Amarkantak Thermal power Plant following materials and methods were followed:-

- Description of the study area
- Study Period
- Water sampling and testing in the Laboratory

Description of the study area:

Chachai Dam is a multipurpose River Valley project on River Sone located inside the Gangas Basin in Madhya Pradesh, at village Chachai in Anuppur district , at a distance of 172 km from Katni and 30km from Shahdol, located at latitude 23- 10' N and longitude 81' 30" E. Its catchment area is 25 square miles.The River Sone originated from the Satpura hills of Amarkantak. Itpasses through Anuppur, Amlai, Biruhli, Navalpur, Diyapiper, Kshir Sagar and Masiraghat and finally reaches to Deolond where a multipurpose dam is constructed by the Government of Madhya Pradesh with collaboration of Govt. of India namely Bansagar dam having an catchment area of 18648 km².

The distance between Amarkantak Thermal Power Plant and Chachai Dam was recorded 2.6 km. I selected two sampling sites for water collection first one was near Thermal Power Plant whereas next was about 02 km faraway from the plant near Chachai Dam. I selected two sites according to their surrounding for detecting quality of water in Chachai Lake on Sone River.

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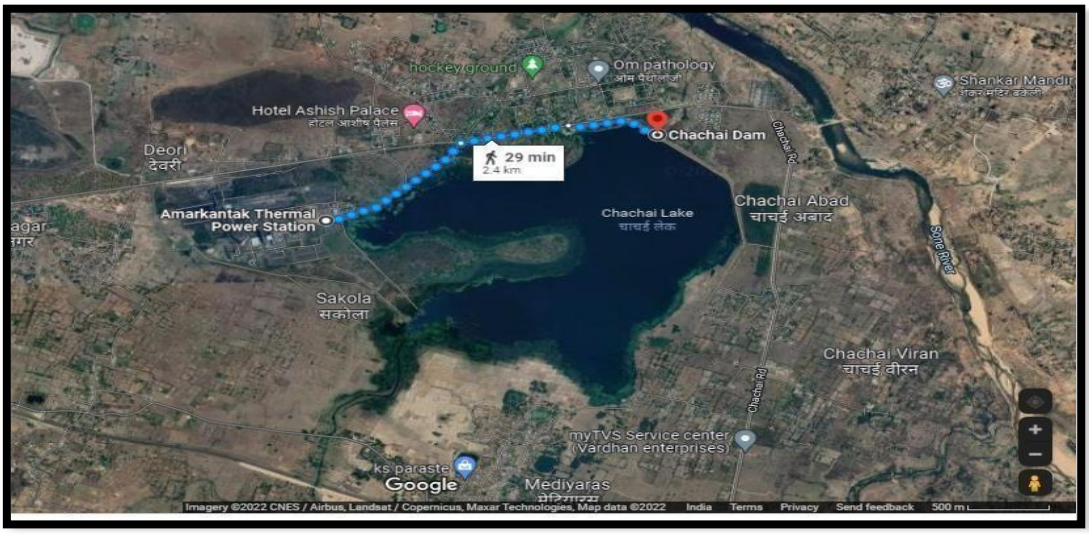

Image-3 :-Showing 2.4Km distance between Amarkantak Thermal power station and Chachai Dam

Study period: The study was done during 2018-2021.

Water sampling:

The water samples were collected from both two sites in different tree seasons of the year (summer, winter and monsoon) during 2018 to 2021. Polythene bottles were used for the collection of water samples. Parameters as water temperature, pH and TDS were recorded at the time of sample collection by using laboratory Thermometer, Pocket Digital pH meter and TDS Meter respectively. The water samples were brought to the laboratory for further study.

Standard Methods for Analysis:

The water samples were analyzed for Physico-chemical parameters in order to find out the level of pollution. For measuring water parameters 2005 version of APHA were followed. Time and space for sampling were maintained throughout the study period.

The quality of the water we use in municipal or industrial processes must be follow specific standards. For example, the Environmental Protection Agency (EPA) has set permissible limits for more than 90 different pollutants found in water. These limits are necessary to ensure that drinking water remains free of contaminants that can cause health problems or the development of waterborne diseases.

There are three water quality parameters that help to measure water quality, including physical parameters, chemical parameters, and biological parameters. The physical parameters include order, taste, color, temperature, turbidity, electrical conductivity and solids. The chemical parameters include pH, alkalinity, hardness, dissolved oxygen (DO), chlorine etc.

Turbidity Measurement: -Turbidity show that how cloudy water is. If turbidity of water is high, it indicates higher concentration of soil, silt and organic materials in water. Water turbidity measured by digital turbidity meter (Metzer Metz 501M, 1 6v-1Amp. (Tungsten Lamp 0 to1000 NTU). NTU means, Nephelometric Turbidity Unit, the unit used to measure the turbidity of a fluid.

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Measurement of water Temperature:- Some aspects of water quality that are affected by water temperature include chemical reactions, odor, solubility, viscosity and palatability. As such, biological oxygen demand, sedimentation and chlorination all depend on water temperature. Ideal water temperature ranges from 50-60 degrees Fahrenheit.

Water temperature was measured by Laboratory thermometer. Laboratory thermometer is used for measuring temperature other than human body temperature. It ranges from -1 to 110^{o}C. It is designed for the laboratory purposes for measuring freezing point, boiling point and the temperature of other substances in the laboratory.

pH measurement: - Two instruments were used for pH measurement. Portable pH meter (Thermocare pH meter-pH- 107) was used to measure pH in the field while Digital pH meter model-Electronics India Alpha 01 (pH range 0 to 14.00) was used in the laboratory. Aquatic lives including fish need a pH range of 6.0 to 9.0.

Measurement of Total Dissolved Solids:-

Digital TDS meter was used for the measurement of TDS. Water is a universal solvent due to its ability to liquefy and absorb molecules from different materials, and the number of dissolved particles in the volume of water is called the total dissolved solids level. The total dissolved solids can be either organic or inorganic.

Total dissolved solids (TDS) is the amount of organic and inorganic substances, such as metals, minerals, salts and ions, that are dissolved in a particular volume of water; TDS is essentially a measure of anything dissolved in water that is not anH_2O molecule. Since it is a solvent, when water meets a soluble material, the particles of the material are absorbed into the water, forming an aggregate of dissolved solids. TDS can come from almost anywhere in water, including natural springs, chemicals used to treat urban water supplies, runoff from roads and courtyards, and even home plumbing system are included. The typical dissolved solids present in water are Ca, Cl, Mg, K, Zn, Al, Cu, Pb, As, Fe, Na, Fluoride, Bicarbonates, Sulphates, Pesticides and Herbicides.

Measurement of Total Alkalinity:

Aquatic lives need 6.0 - 9.0 pH range. Because alkalinity reacts or buffers against fast pH changes, the alkalinity saves the existing organisms that require a definite pH range. High alkalinity levels in surface waters can buffer acid rain and other acid effluents. It can prevent pH changes that are dangerous to aquatic life. It used to be additionally decided by using titration with 0.02 (N) H_2SO_4. Methyl orange and phenolphthalein were used as indicators.

Measurement of Total Hardness: -

Hardness of water used to be calculated using titration method EDTA. Water is hard, which means it contains high amounts of naturally dissolved calcium and magnesium. The total hardness in milligrams per liter (mg/L) is the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate. We can find out the hardness of water-based on these concentrations of calcium carbonate.

Measurement of Chloride:- The Mohr method uses silver nitrate (normality: 0.0141) for titration. 1 ml of 0.0141 is equal to 1 mg of chloride in solution. Silver nitrate solution is standardized against the standard chloride solution prepared from sodium chloride (NaCl). During the titration, the chloride ion is precipitated. Potassium chromate is used as an indicator.

Measurement of Dissolved Oxygen (DO):- Winkler's method was used for determining

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DO in sample water. Water carefully sampled in a 100 ml reagent bottle. Manganese sulphate and potassium iodide (alkaline) were used as a fixative. After forceful shaking of the bottle a thick precipitate emerged. Precipitate dissolved using Con. Sulphuric acid. Sample aliquot was titrated against $Na_2S_2O_3$ of 0.025 normality using indicator (1% starch).The loss ofthe blue color determines the end point.

Heavy Metal detection: - Atomic Absorption Spectrophotometer (AAS-ELICO, SL 168) was used for the determination of the heavy metals (Pb, Fe, Cr, and Al) in water samples (APHA, 1985).

Observation:

Observations were made in the following heads:-

• Results of water testing in the laboratory

Results of water testing in the Laboratory:

The Physico-chemical data of the water samples collected from two different sites of the Chachai Dam are summarised here in the table 1, 2 & 3. Samples were analyzed in three seasons (summer, monsoon and winter) of the year.

Table:-1. Showing physico-chemical data of the water of Chachai Dam during summar season

S.N	Parameters	BIS-10500/WHO	Site-1	Site-2	Unit
	Physical Parameters				
1	pH	6.5-8.5	7.1	6.2	-
2	Temp	-	24.5	24.0	-
3	Turbidity	5	69	25	NTU
4	TDS	500	220	159	Mg/l
	Chemical Parameters				
5	Dissolved oxygen (DO)	-	8.3	9.4	Mg/l
6	Total Alkalinity	200	127	122	Mg/l
7	Total Hardness	300	180	111	Mg/l
8	Calcium Hardness	-	113	69	Mg/l
9	Magnesium Hardness	-	49	37	Mg/l
10	Chloride	250	57	19	Mg/l
11	Aluminium (Al)	0.2	18.30	17.70	Mg/l
12	Lead (Pb)	0.05	17.2	15.3	Mg/l
13	Iron (Fe)	0.3	15.67	11.30	Mg/l
14	Chromium(Cr)	0.03	2.6	2.4	Mg/l

*Bureau of Indian Standard (10500-2012)

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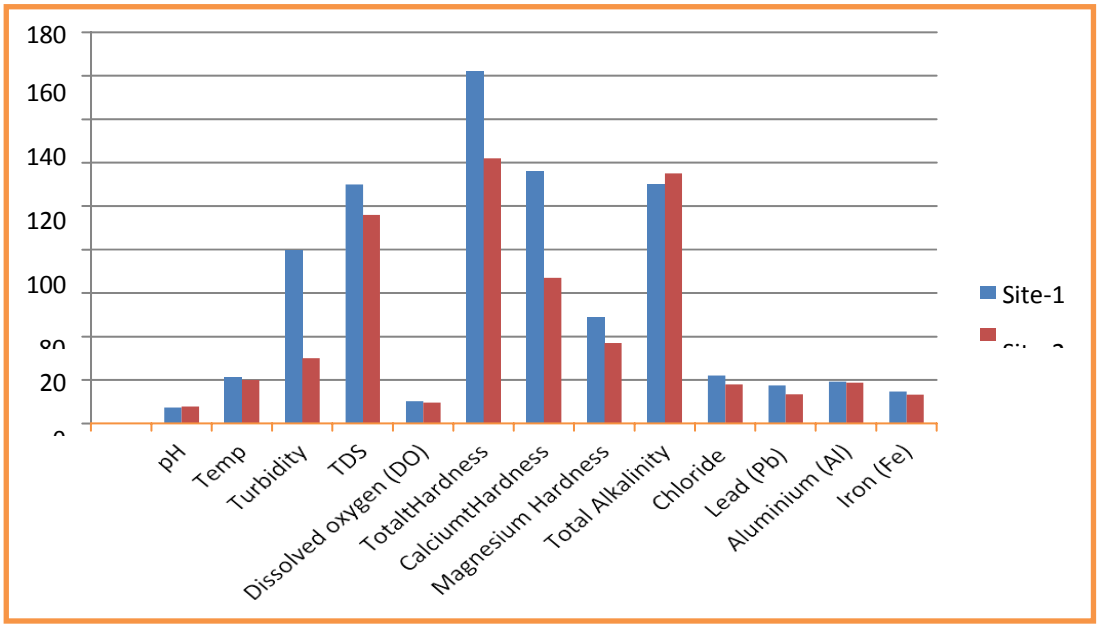

Figure-1: - Histogram showing physico-chemical data of the water of two study sites during summer

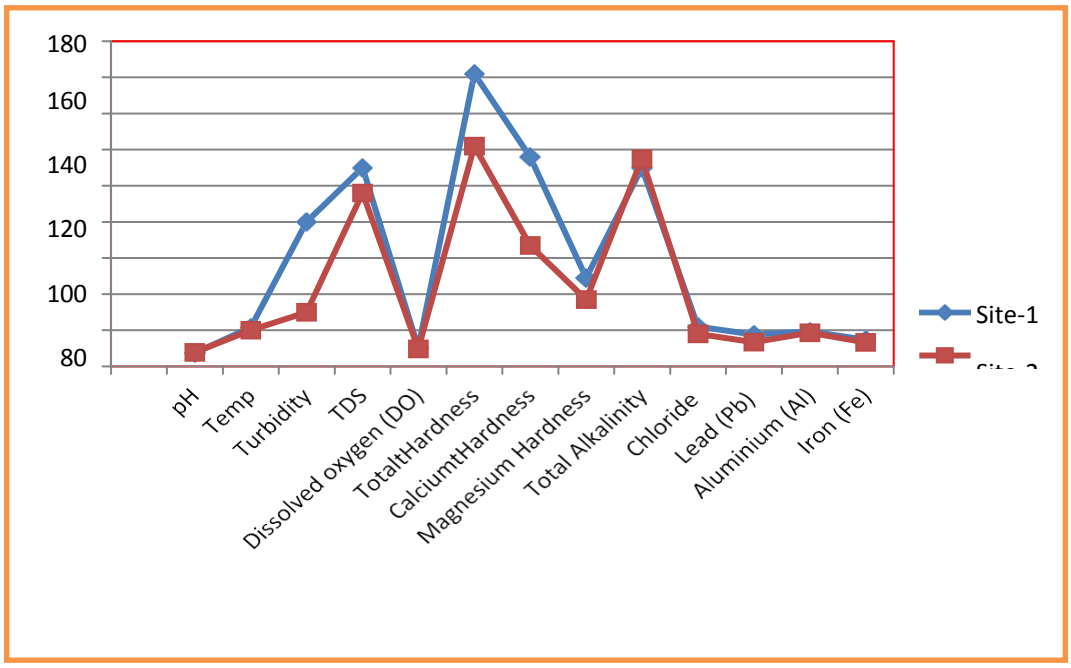

Figure-2: - Graph showing physico-chemical data of the water of two study sites during summer

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Table:-2. Showing physico-chemical data of the water of Chachai Dam during Monsoon season

S.N	Parameters	BIS-10500/WHO	Site-1	Site-2	Unit
	Physical Parameter				
1	pH	6.5-8.5	6.6	6.5	-
2	Temp	-	23.0	23.0	-
3	Turbidity	5	120	115	NTU
4	TDS	500	160	126	Mg/l
	Chemical Parameter				
5	Dissolved oxygen (DO)	-	8.3	9.4	Mg/l
6	Total Alkalinity	200	123	108	Mg/l
7	Total Hardness	300	114	110	Mg/l
8	Calcium Hardness	-	70.6	65.4	Mg/l
9	Magnesium Hardness	-	40.5	37.6	Mg/l
10	Chloride	250	25	19	Mg/l
11	Aluminium (Al)	0.2	19.20	19.18	Mg/l
12	Lead (Pb)	0.05	19.2	18.3	Mg/l
13	Iron (Fe)	0.3	15.3	13.20	Mg/l
14	Chromium(Cr)	0.03	2.7	2.5	Mg/l

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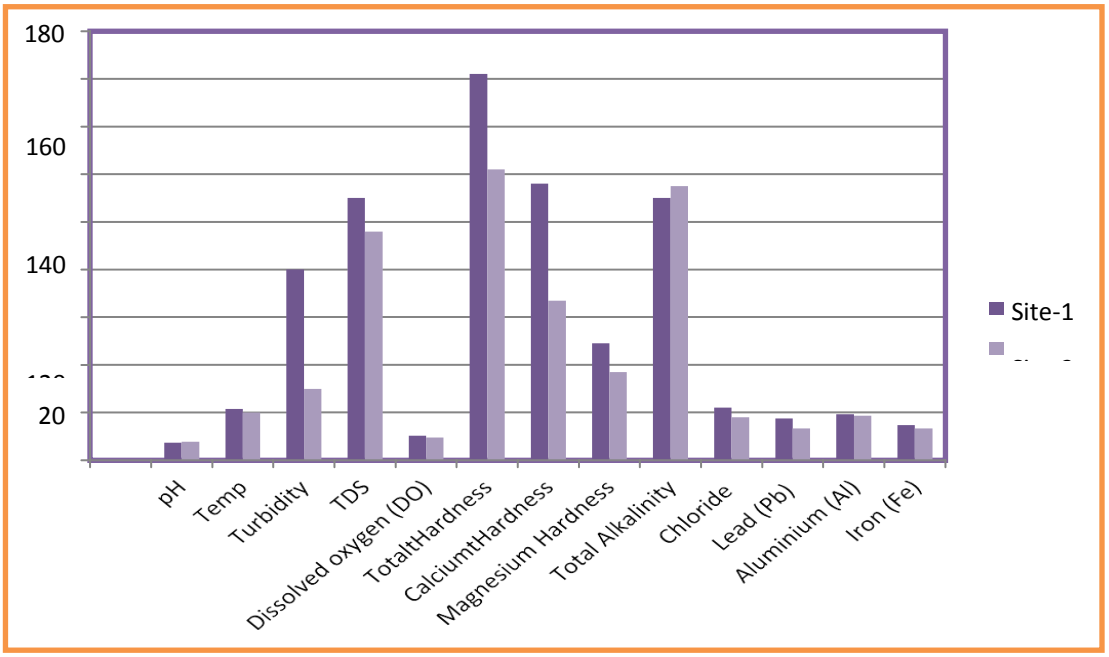

Figure-3:-Histogram showing physico-chemical data of the water of two study sites during monsoon

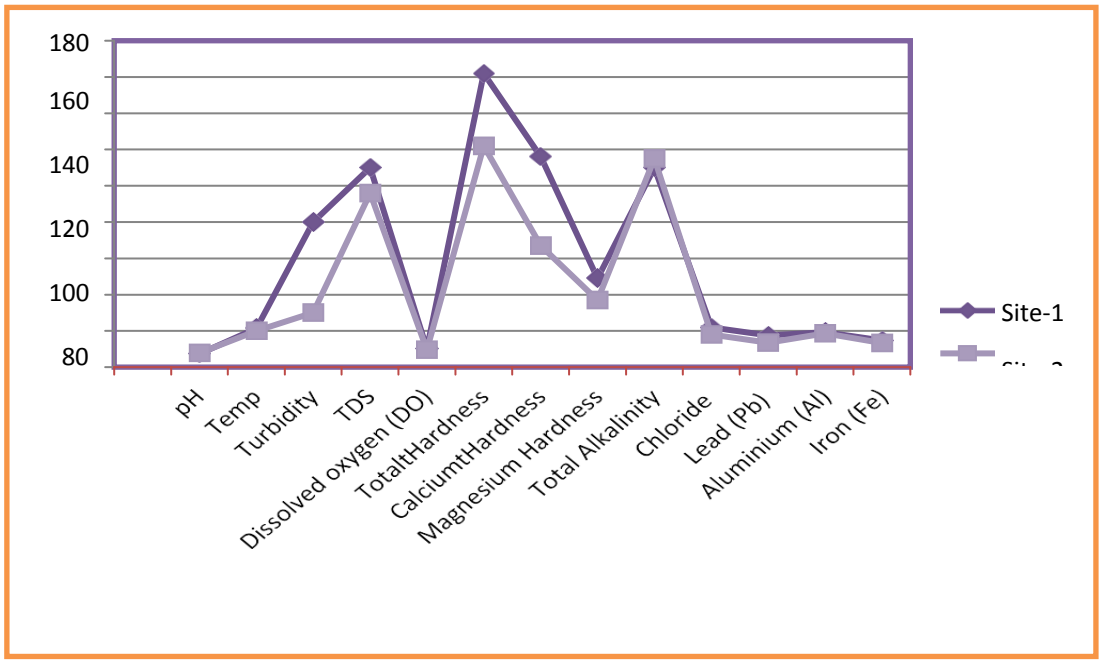

Figure-4: - Graph showing physico-chemical data of the water of two study sites during monsoon

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Table:-3. Showing physico-chemical data of the water of Chachai Dam during winter season

S.N	Parameters	BIS-10500/WHO	Site-1	Site-2	Unit
	Physical Parameter				
1	pH	6.5-8.5	7.35	7.81	-
2	Temp	-	21.5	20.0	-
3	Turbidity	5	80	30	NTU
4	TDS	500	110	96	Mg/l
	Chemical Parameter				
5	Dissolved oxygen (DO)		10.2	9.6	Mg/l
6	Total Alkalinity	200	110	115	Mg/l
7	Total Hardness	300	162	122	Mg/l
8	Calcium Hardness	-	116	67	Mg/l
9	Magnesium Hardness	-	49	37	Mg/l
10	Chloride	250	22	18	Mg/l
11	Aluminium (Al)	0.2	19.30	18.70	Mg/l
12	Lead (Pb)	0.05	17.5	13.4	Mg/l
13	Iron (Fe)	0.3	14.67	13.30	Mg/l
14	Chromium(Cr)	0.03	2.5	2.2	Mg/l

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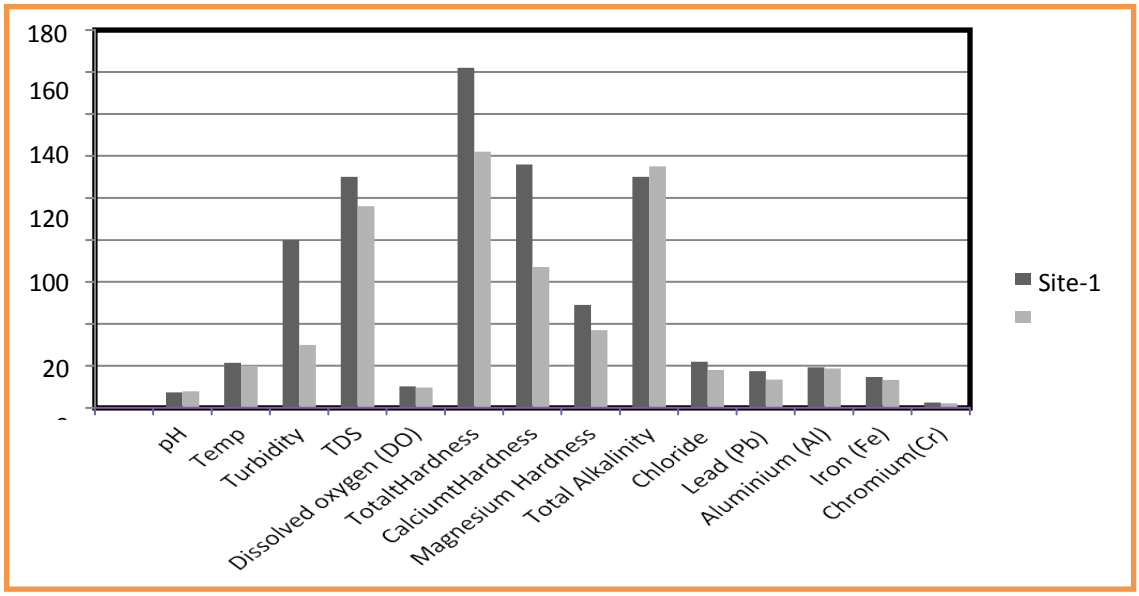

Figure-5:-Histogram showing physico-chemical data of the water of two study sites during winter

As shown in Table-2, 3 and 4, in all three seasons' turbidity of the water were much higher than the permissible limits. The contamination level of four metals as Lead (Pb), Aluminum (Al), Iron (Fe) and Chromium (Cr) also were high, exceeding WHO target values.

Heavy metal has been widely used as a group name for metals and semimetals that are associated with contamination and potential toxicity or ecotoxicity. These metals have been extensively used in various materials of industrial and domestic use. Due to their widespread and common uses, their entry into the vital system of the organism through food, drinking water and even air cannot be denied. Interestingly, small amounts of the metals are essential for health, but large amounts of any of them can lead to acute or chronic toxicity.

Discussion:

Water quality in any ecosystem provides significant information about the resources accessible to support life in that ecosystem. Several physicals, chemical and biological parameters of water indicate the quality of waterbodies that can vary under the toxic effects of pollutants.

In the present observation, in water, the concentration of metals such as Pb, Al, Fe, and Cr was found much higher than the permissible limits prescribed by WHO and Indian Standards.

Currently, Pollution has become a universal problem and each country is responsible for this because of its anthropogenic activities, sewage, and industrial waste disposal, mining, and leaching. We are polluting our environment directly or indirectly for our selfishness. In particular, aquatic bodies are getting polluted by us due to increasing industrialization and urbanization. Various type of pollutants contaminates our water bodies, the major concern is towards heavy metals.

Conclusion:

- Coal Flyash is responsible for the aquatic pollution proved by present

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study.

- The Sone River is being contaminated because the power plant disposed ash mixed hot waste water on the Sone River and consequently it has an adverse impact on the river. So the physical and chemical parameters of the river altered.
- In water samples, the concentration of metals such as Pb, Al, Fe and Cr were found much higher than the permissible limits prescribed by WHO and Indian Standards.
- India has to strictly control the disposal of toxic fly ash from coal-fired power plants to reduce environmental and health hazards to local communities.
- A lot of attention is given to the mining and coal burning that leads to huge carbon emanation.
- Despite the risks to our health and the environment the dangers of coal fly ash, the remains left after coal combustion in thermal power plant, have received less public attention.
- According to the report, Madhya Pradesh(M.P), Odisha, Jharkhand, West Bengal, Tamil Nadu, Chhattisgarh and Maharashtra have the highest number of coal-fired thermal power plants, and top the list of coal fly ash accidents.

Suggestion:

- After the combustion of coal, fly ash should be properly treated.
- Continued monitoring of metals and other pollutants in water bodies.
- National environmental quality standards for water and toxic metal content in fish should be created and implemented.
- Government authorities as pollution control board, Public health and engineering departments, irrigation departments should understand their responsibilities for environment and implemented that properly.

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