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Research Paper

The impact of coal fly ash of Amarkantak thermal power station on the Liver of selected commercial fish (*Channa punctatus)*

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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 contents whereas 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. 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. Different metals are stored in different ways in different parts of fishes. After bioaccumulation they cause tissue degeneration in different organs like Liver, Kidney, Gills, Skin and Intestine.

Keywords: Coal Fly Ash, Chemical Composition, Heavy Metals, *Channa punctatus*, Amarkantak Thermal Power Plant.

Introduction:

Interest in fly ash and 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

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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 2008. According to many workers such as Kumar (2003), Mishra (2004), and Saravan et.al., (2008), India produced its seventy percent of electricity 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 and Shyam in 2002, the electricity generation in India in 1947 was 1362 MW while in 2002 it increased to about 105000 MW.

Power plants mainly coal based stations are most vulnerable to water bodies and its ecosystem. Because after burning the coal, the water from the nearest water bodies is usually used for cooling in thermal stations and released back. This discarded water has a significant high temperature that can alter the biological activities of the organisms that live in it as described by Srivastava and Srivastava in 2012. High temperature also alters the dissolved oxygen in water. Because fish are very important members of the food chain in aquatic ecosystems, it is necessary to evaluate the toxic effects of metals on them. Most of the metals are absorbed by the fishes through gills, skin and digestive system and accumulate in different tissues. As explained by the Nussy in 1998, Heavy metals once absorbed through the gills or intestine, undergo metabolism and alter the structure and function of various biological molecules like DNA, RNA, Proteins and the enzyme's cofactor. These changes can cause many tissue abnormalities and lead to diseases.

Different metals are stored in different ways in different parts of fishes. After bioaccumulation they cause tissue degeneration in different organs like Liver, Kidney, Gills, Skin and Intestine. Heavy metals may also alter the blood composition, immunity loss and a number of physiological imbalances and adverse histopathological conditions. All these ultimately affect the growth, survival and fertility of the fish. The aim of the present study is to add some new facts about the effects of coal fly ash on selected experimental fish *Channa punctatus*. So far no workhas been done in the Shahdol area to add new facts about the metal pollutantsof fly ash and its effect on fishes. While there are many, about 50 coal mines in Shahdol division and thermal power plants are in working condition.

Biology of *Channa punctatus*

The *Channa punctataus* is classified under the family Channidae and order Perciformes. These are air-breathing fishes because of accessory respiratory organs. These are suitable for widespread cultivation in tropical or subtropical regions where the availability of freshwater may be limited and dissolved oxygen may be low. These fishes can survive in shallow water even with low oxygen concentration which is why may they can have significant benefits for aquaculture. Considering its tolerance to low dissolved oxygen, it can be cultivated at high densities in concentrated tanks but to reduce cannibalism size grading is essential.

The body of *Channa punctatus* is elongated and bilaterally symmetrical. They are 14.5cm to 20.5 cm in length. The total body is roofed by ctenoid scales. Cycloid scales also have been recorded in these fishes. Their body is wet and slippery due to the secretion of

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mucus from the skin. The dorsal half is achromatic wherever the ventral aspect is yellowish grey in color. The body is divided into three parts, that is; Head, Trunk, and Tail. The head of this fish looks like a snake.The eyes are small in size and located on the anterior of the head. Two pairs of nostrils are found on the head. The lower jaw is somewhat protruding. Conical teeth on lower jaw and barbells are absent. The single dorsal fin and the anal fin enlarge from the posterior end of the anus. It has undivided dorsal and anal fins, supported by spinous bony fin rays. Caudal fin is found Unilobed. The body colour is brown on the back whereas fading to lighter beneath. According to Bhuiyan (1964), the maximum length is 30 cm while Rahman (1989) reported the total length of this fish over 240 mm.

Females are smaller than males in size. Males have black dotes on the ventral region of the body and their urinogenital openings are elongated. The mature females have swollen abdomen though males oozes milts on pressing their abdomen. The recommended temperature for spawning ofthis fish is about 24 to 28 ^{o}C. *Channa punctatus* males are protective and illustrate aggressive behaviour during the spawning season.

Image-1. *Channa punctatus*

Materials and Methods:

To assess the impact of fly ash on the selected experimental fish *Channa punctatus* in the Sone River at Chachai dam near Amarkantak Thermal power Plant following materials and methods were followed:-

- Description of the study area
- Water sampling and testing in the Laboratory
- Determination of Fly ash composition
- Fish sampling
- Calculation of LC50 for Flyash
- Histological slide Preparation
- Microphotography

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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.

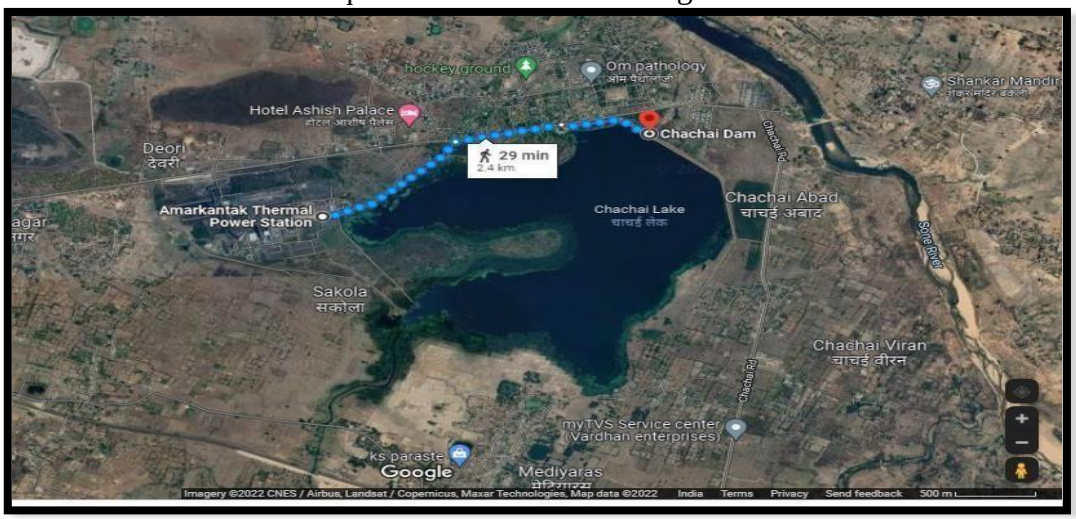

Image-02. Showing 2.4Km distance between Amarkantak Thermal power station and Chachai Dam

Image:-03. Showing Main Gate of Amarkantak Thermal Power Station

The distance between Amarkantak Thermal Power Plant and Chachai Dam was recorded 2.6 km. I selected two sampling sites for water collection first

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one was near Thermal Power Plant whereas next was about 02 km far away 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.

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.

Examination of water samples:
The Physico-chemical parameters as Temperature, pH, Total Dissolved Solids (T.D.S.) Total Hardness (T.H.), Ca Hardness, Mg Hardness, Total Alkalinity (T.A.), Dissolved Oxygen (D.O.), Chloride and metals (Pb, Fe, Cr, and Al) were measured in the laboratory.

Determination of Fly ash composition:
We got the composition of fly ash detected from the pollution control board Jabalpur.

Fish sampling:
We selected *Channa punctatus* for the experiment because it is a bottom-dwelling fish living in direct contact with the fly ash. It is an air-breathing fish and its length is short. Its acclimatization was easy. It required low maintenance. It was easily available and consumed about daily by the poor villagers across the dam.

Calculation of LC 50 for Fly ash/ Acute toxicity Test:

To estimate the median lethal concentration of 96 hours for acute poisoning bioassay was organized. The average lethal concentration is the concentration of test chemicals representing the pollutant that killed 50% of the test animals in stock during a test time. Freshwater teleost fish *Channa punctatus* taken for the experiment were 14.5 to 20.5 cm in length and 40 gram to 60 gram in weight. Prior to the experiment, fishes were brought from the local market. Fishes have been acclimatized in laboratory conditions. Tap water (Dechlorinated) was used for the experiment in the aquarium. Some Water Parameters Maintained like temperature from 26ºC to 30ºC, Dissolved Oxygen from 6.5 to 7.0 mg/L, pH from 7.0 to 7.5, Total Alkalinity from 175 to 180 mg/L, Total Hardness from 100 to 120 mg/L, Free Carbon dioxide from 2.0 to 2.5 mg/L.
Throughout acclimatization, fishes were fed frequently. 24 hours before the experiment feeding was stopped to avoids the interference of excretory materials on the composition of the test solution. 20-liter glass tanks were used for the experiment. In each tank, 10 experimental fish were placed in fifteen (15) liters of water. For each fly ash concentration separate aquarium was exposed. Simultaneously, a non-treated (not exposed to the toxicants) aquarium with 10 experimental fish was also maintained. A set of 4 glass tanks were used for one concentration of fly ash. Means for the test of one concentration of fly ash four replicates were used. Diverse concentrations of fly ash were prepared for the test which was dissolved in water and then added to the test medium.
First, a rough range determining test was performed to determine the dosage range of fish at which mortality takes place. The different amount of fly ash used in the acute toxicity test is summarized in

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Table-02. Every 24 hours, the mortality rate of the test fishes was recorded and all dead fishes were counted. Dead fish were immediately removed from the experimental aquarium to avoid any pathogenic contamination in the aquarium. Water was changed after 24 h in all test aquariums. As explained by the previous researchers like Al-Attar in 2005 and Dhara et al., in 2013 in their literature. After 96 hours, the mortality rate of the experimental fishes were used to determine the LC 50 value using USEPA-1999 computer software. .

Observations:

Observations were made in the following heads:-

- Results of water testing in the laboratory
- Value of LC 50 for Flyash
- Histopathological observations of target organs (Liver)

Results of Water Testing in Laboratory:

The Physico-chemical data of the water samples collected from sites of the Chachai Dam are summarised here in the table 1. 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 summer, monsoon & winter season.

S.N	Parameters	BIS-10500/WHO	Summer Seasons	Monsoon Seasons	Winter Seasons	Unit
	Physical Parameters					
1	pH	6.5-8.5	7.1	6.6	7.35	-
2	Temp	-	24.5	23.0	21.5	-
3	**Turbidity**	**5**	**69**	**120**	**80**	**NTU**
4	TDS	500	220	160	110	Mg/l
	Chemical Parameters					
5	Dissolved oxygen (DO)	-	8.3	8.3	10.2	Mg/l
6	Total Alkalinity	200	127	123	110	Mg/l
7	Total Hardness	300	180	114	162	Mg/l
8	Calcium Hardness	-	113	70.6	116	Mg/l
9	Magnesium Hardness	-	49	40.5	49	Mg/l
10	Chloride	250	57	25	22	Mg/l
11	**Aluminium (Al)**	**0.2**	**18.30**	**19.20**	**19.30**	**Mg/l**
12	**Lead (Pb)**	**0.05**	**17.2**	**19.2**	**17.5**	**Mg/l**
13	**Iron (Fe)**	**0.3**	**15.67**	**15.3**	**14.67**	**Mg/l**
14	**Chromium(Cr)**	**0.03**	**2.6**	**2.7**	**2.5**	**Mg/l**

*Bureau of Indian Standard(10500-2012)

As shown in Table-1, 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,

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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. Heavy metals are found naturally in the earth. They become concentrated as a result of man-made activities and can enter plant, animal and human tissues through inhalation, feeding, and manual handling. Again, they can interfere with the functioning of important cellular components.

Value of LC 50 for Fly ash:

The aim of the observation was to get data for the range of fly ash concentration causing adverse effects in the experimental fish with the exposure time limit in order to establish the toxicity of fly ash based on a doseresponse relationship as explained by Moore (1984). Different dose of fly ash were given to test fishes under experimentation. Throughout the experiment, it was observed that there was an increase in mortality in fish as a result of a continuing increase in the concentration of coal ash. In different experimental time period the mortality rate of test fishes and Sub Lethal concentration (LC 50) of fly ash were noted and calculated using Finney Probit Analysis Method 1971. The obtained values of LC50 for fly ash in present experiment at standard time periods (24 h, 48h, 72 h and 96 h) are given below in Table-2

Table-2:-Showing Fly ash concentration and mortality percentage for *Channa punctatus*

	24hours	**48hours**	**72hours**	**96hours**
Con.of Flyash (g/L)	Mortality percentage	Mortality percentge	Mortality percentage	Mortality percentage
1.0	10	10	10	10
3.25	10	10	20	20
3.50	10	10	20	30
4.50	10	20	30	40
5.25	20	20	40	40
6.25	20	20	40	50
6.50	30	30	50	60
7.50	40	30	50	70
8.25	40	50	60	70
9.50	50	60	70	80
10.0	60	70	90	90

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Table-03:-LC 50 values of fly ash concentration for *Channa punctatus*

S.N.	Duration	LC50values
1	24 hour's	15.98
2	48 hour's	11.02
3	72 hour's	08.33
4	96 hour's	06.02

Histopathological Observations of Target Organs (Liver):

Histopathological alterations have been extensively used as a biomonitoring tool to refer to the health status of fish exposed to environmental pollutants. Fishes are commonly used for histological studies to know the structural changes that occur in organs due to the effects of pollutants. These structural changes vary with the nature of pollutants, body parts, duration of exposure and quality of the medium. In present experiment, the response of a liver and kidney offish (*Channa punctatus*) to sub lethal concentrations of fly ash (6.02g/L) has been studied. In the present observation, as compared to the control fish, flyash treated fish was found to be sick with skin rashes and erythematic (skin redness) condition. It was also observed that the color of the skin changed. After six-seven days of treatment excessive secretion of mucous were observed. It showed the adaptive behaviour of the fish against flyash because mucous protect as a barrier between skin and pollutants. During observation on liver tissue it was found that, there were many histological alterations in the liver of treated fish. It was unhealthy liver with histomorphological changes as evidenced by Vacuolation, condensation of cytoplasm, hemorrhage and necrosis (Image-04). Whereas, healthy liver tissues were found in control fishesas shown in images-05.

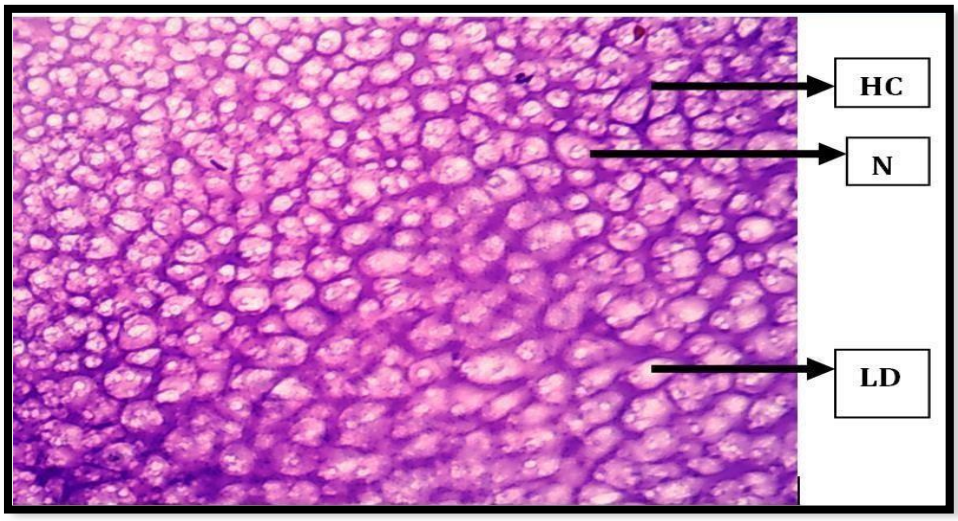

Image-04:-T.S. of Liver of *Channa punctatus*, illustrating normal structure of Liver showing polygonal hepatocytes(HC), Lipiddroplets(LD) and nucleus(N) (X400-5µ)

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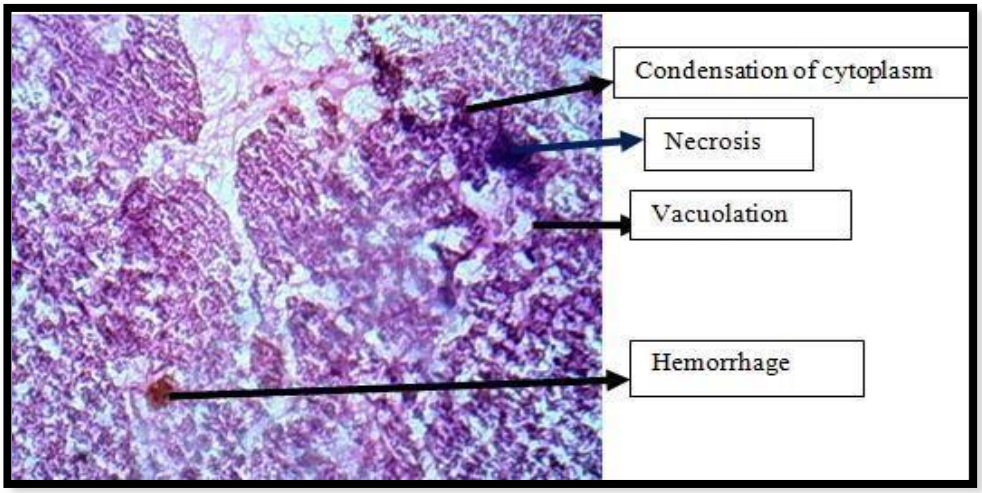

Image-05: T. S. of Liver, Illustrating the histomorphological changes in the liver of *Channa punctatus* as evidenced by condensation of cytoplasm (CC), Vacuolation (V), Necrosis (N) and Hemorrhagichepatocytescells.(X150-5µ)

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 water bodies 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. It is also a known fact that the presence of metals in the form of pollutants is very dangerous to such an extent that although in very small amounts but for a long time and in a sustained manner their presence has proved to have harmful effects on the aquatic organisms.

Fish and alternative aquatic animals absorb various metals from their food still as from the water that passes through their gills. The absorption of various metals usually depends on the amount eaten and the number of various metals within the food of prey. Heavy metals ensuing from the development of industry and it's unharnessed into water, are immune to decomposition and its quantity accumulates in fish mutually of the human food chains. The most disadvantages of various metals are that they are not metabolized within the body. In fact, various metals are not expelled from the body after entering and accumulate in body tissues. This causes several diseases and complications within body. They additionally increase the expansion and spread of 100 microorganism, bacterial and fungal infections. Various metals also replace different salts and minerals required by the body. For example, various metals build up within the tissues of arteries, muscles, bones, and joints, or are replaced by metallic element in the case of deficiency disease in food.

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Conclusion & Suggestion:

- Coal Fly ash is responsible for the aquatic pollution proved by present 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 present study metals reported in fly ash as Manganese (0.92) <Chromium (1.6) <Sulphate (2.46) <Potassium (2.92) <Magnesium oxide (3.02) <Iron (14.68) <Lead (18.2) <Aluminum oxide (18.34) <Silicon dioxide (47.32)
- 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.
- Experimental fish, *Channa punctatus* exposed to coal fly ash and the toxic level were expressed in terms of LC50 value.
- The sub lethal (LC50) values evaluated for *Channa punctatus* were found to be 15.98, 11.02, and 08.33, 06.02 g/l for time limit of 24h, 48h, 72h and 96hrs.
- The percentage of survival of fish observed decreasing with the increasing concentration and time period of exposure.
- Present study shows relationship between the time period of exposure and concentration of fly ash. Although very less or almost no data are available on the toxic level of concentration of coal fly ash to fish.

CONCLUSION & SUGGESTIONS

- Alterations in the liver tissue of experimental fish proved the toxic effects of flyash not only on fish but also on other aquatic flora and fauna.
- Coal fly ash is a serious threat to our health, aquatic animals, and the environment.
- 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.

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