

Physico-Chemical and Biological Environment of the Abandoned Coal Quarries for Possibility of Fish Culture

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Abstract – Coal quarry is the abandoned mines surface pit after mining of the coal. There are number of such surface pit available in Jharkhand. These surface pits are filled with rain water and remain fallow. Some coal quarries water is used for irrigation and non-domestic purposes.

The present work was to study the Physico-chemical and biological parameters of the coal quarries to study the possibilities of fish culture in these surface pits. The analysis of four coal quarries has been done from 2008 to 2010. The findings revealed that Physico-chemical parameters are within favorable range of fish culture except the low alkalinity and poor concentration of plankton (natural food of fish). The heavy metals were present in sediment, water, plankton and fish muscle. The heavy metals i.e. iron, cobalt, nickel, copper, zinc, manganese, cadmium, lead and mercury is present sediment, water, plankton and fish muscle. The abundance order of metals were Fe > Zn > Pb > Mn > Cu > Ni > Co > Cd > Hg in sediment and Fe > Zn > Mn > Cu > Pb > Ni > Cd > Co > Hg in water, Zn > Pb > Cu > Ni > Fe. Mn > Pb > Co > Hg in plankton and Fe > Zn > Mn > Pb > Ni > Cu > Co > Hg in fish muscle the concentration of heavy metals are sediment > water > fish muscle > plankton.

The heavy metals in water were below the maximum permissible level of drinking water but it was more than the concentration of heavy metal for continuous exposure of the fish. The fish analyzed for heavy metals was young wild fish. When the coal quarry was stocked with cultivable varieties there was poor survivability.

As per the above finding it has been found that there is need of further study for selection of fish varieties, culture practices, biological method to reduce the heavy metals, harvesting methods and to decide the safest age of the fish for the consumption.

Keywords - Coal Quarries, Fish Culture, Heavy Metals, Physico-Chemical Parameters.

I. INTRODUCTION

Coal quarries is the abandoned surface pit left after the open cast coal mining filled with rain water remain isolated and fallow. There are many such surface pit having areas ranging 1-25 ha and depth 30-150 ft. scattered in the mining areas of whole state under the

jurisdiction of CCL, BCCL etc. The left over coal/low valued coal is dumped on the periphery of the surface pit. These pits received water during rainy season from the surrounding catchment area and stored in these pits up to 9-12 months. Stored water generally used for irrigation purpose by the farmers to irrigate nearby cultivated area, villagers also used this water for domestic purposes except drinking. Some wild fishes are also available in these water bodies which are being consumed by the local villagers.

There is possibility to utilize these water bodies for scientific fish culture practice, it will not only increased the fish availability in the surrounding area but also improve the livelihood of the villagers. But before starting the fish culture for human consumption it is important to critically assess the Physico-chemical and biological environment including content of heavy metals in coal quarries.

II. MATERIALS AND METHODS

Considering the importance of the study mining areas were surveyed and four coal quarries namely Ambakhad, Hesagarh, Block: Kuju, District: Ramgarh (N 23°45.937' E 85°30.485'), Coliery no. 13 (Arah) Block: Kuju, District: Ramgarh (N 23°44.842' E 85°33.361') Coliery no. 2 (Laddi) Block: Bhurkunda, District: Ramgarh (N 23°38.992' E 85°22.399') and Coliery no. 3 (Lapanga) Block: Bhurkunda, District: Ramgarh (N 23°38.841' E 85°22.569') were selected for the study. The soil and water sample were collected and brought in the laboratory and analysed as per APHA (1995) for Physico-chemical and biological parameters. The physico-chemical and biological parameters of the water were studied in the three different seasons (April, August, December) from 2008-2010. The soil and water were also studied for heavy metals from NOVA 60 (Merck) and Atomic Absorption Spectrophotometer. The sample of Soil, Water, Plankton and Fish were analyzed from Steel Authority of India Ltd. (SAIL) laboratory, Ranchi through ICP.

III. RESULTS AND DISCUSSION

Table I: Physical parameters of water of coal quarries

S. No.	Physical Parameters	Name of the coal quarries			
		Coal quarry-3 Lapanga	Coal quarry -2 Laadi	Ambakhad	Coal quarry-13 Aarah
1	Temperature (Air) °C	18-34	18-34	18-33	18-33

2	Temperature (Water) °C	15-31	15-31	14-30	15-30
3	Colour of water	Clear-brownish green	Clear- Bluish green	Clear- Brownish green	Clear-Bluish green
4	Transparency (in cm)	29.5-32	28.5 -34	26.5 -30	29.5 -32.5
5	TDS (mg/l)	110-160	70-92	130-171	130-179
6	Salinity (ppt)	0	0	0	0
7	pH	7.0-7.88	7.0-7.67	7.0-7.52	7.0-7.97

Table II: Chemical & Biological Parameters of water of coal quarries

S. No.	Biological Parameters	Name of the coal quarries			
		Lapanga Coal quarry-3	Laadi Coal quarry-2	Ambakhad	Aarah Coal quarry-13
1	Electrical conductivity (µS/cm)	210-296	140-169.8	250-316	240-332
2	DO (ppm)	7.8-8.8	8.5-9.2	7.8-8.4	7.6-8.2
3	Plankton status The quantitative plankton status ranges from 0.2 to 0.3 ml/100 lit of water.	The plankton status is poor except the Ambakhad coal quarries may be due to poor organic matter in the bottom. The available phytoplankton is mainly from Myxophyceae, Chlorophyceae and Bacillariophyceae group, the zooplankton is from Rotifer, Copepoda and Cladocera group.			
4	CO ₂ (ppm)	0 -15	0 -18	0 -18	0 -18
5	Alkalinity (ppm)	68-72	52-60	62-68	50-58
6	COD (ppm)	76 -85	68 -80	66 -80	70 -82

Table III: Plankton Concentration in coal quarries

Period	Family	C.Q.NO-13	LAADI	LAPANGA	AMBAKHAD
August 2008	Phytoplankton (%)	63.52	58.82	54.47	52.25
	Myxophyceae (B.G.Algae)	38.89	38.23	33.60	37.50
	Chlorophyceae (Green algae)	31.48	36.47	35.16	31.25
	Bacillariophyceae (Diatoms)	29.53	25.30	31.34	31.25
	Zooplankton	36.48	41.18	45.53	47.75
	Rotifera	48.38	53.78	41.12	42.73
	Copepoda	26.88	24.36	20.56	29.05
	Cladocera	24.74	21.86	38.32	28.22
December 2008	Phytoplankton	57.39	55.31	55.07	58.77
	Myxophyceae (B.G.Algae)	37.42	37.69	42.55	37.50
	Chlorophyceae (Green algae)	31.90	28.34	26.95	30.55
	Bacillariophyceae (Diatoms)	30.68	33.85	30.50	32.35
	Zooplankton	42.62	44.69	44.93	41.23
	Rotifera	44.62	43.81	44.35	44.55
	Copepoda	28.10	27.62	28.70	25.74
	Cladocera	27.28	28.57	26.95	29.71
April 2009	Phytoplankton	60.51	60.33	56.55	57.78
	Myxophyceae (B.G.Algae)	39.04	33.56	39.13	38.92
	Chlorophyceae (Green algae)	30.48	33.14	31.88	28.74
	Bacillariophyceae (Diatoms)	30.48	36.30	28.99	32.34
	Zooplankton	39.49	39.67	43.45	42.22
	Rotifera	42.99	43.75	47.18	42.62
	Copepoda	24.97	28.12	26.41	23.77

Period	Family	C.Q.NO-13	LAADI	LAPANGA	AMBAKHAD
August 2009	Cladocera	28.24	28.12	26.41	33.61
	Phytoplankton	58.5	62.45	64.61	50.4
	Myxophyceae(B.G.Algae)	38.89	43.03	39.53	37.50
	Chlorophyceae(Green algae)	31.48	25.94	28.48	31.25
	Bacillariophyceae(Diatoms)	29.53	31.03	31.99	31.25
	Zooplankton	4105	37.55	35.59	49.6
	Rotifera	48.38	43.16	41.05	42.73
	Copepoda	26.88	23.16	25.26	29.05
	Cladocera	24.74	33.68	33.69	28.22

Table IV: Heavy metals in Coal quarries

Heavy metals	Soil (ppm)	Water (ppm)	Plankton (ppm)	Fish (ppm)
Fe	14.11-35.32	0.77-2.01	BDL-0.029	0.3321-0.92
Co	0.004-0.043	0.002-0.004	BDL-0.004	BDL-0.004
Ni	0.001-0.070	0.003-0.008	0.003-0.004	0.009-0.0412
Cu	0.040-0.280	0.019-0.042	0.003-0.040	BDL-0.1928
Zn	2.200-4.200	0.220-0.880	0.350-0.360	0.200-1.3933
Mn	0.280—0.470	0.036-0.160	BDL-0.008	0.016-0.2337
Cd	BDL-0.002	0.003-0.005	BDL-0.008	BDL
Pb	0.474-0.690	0.020-0.032	0.015-0.024	0.0148-0.063
Hg	BDL-0.001	0.001-0.002	BDL-0.001	BDL-0.001

A number of limnological parameters were also analyzed in the field i.e. pH, Temperature, Dissolved Oxygen, Alkalinity, and Conductivity etc. These parameters are always considered as good indicators of the quality of water of a particular coal quarries. The quality of water of a coal quarry is greatly affluence by the chemistry of the coal seam and local geology.

The water temperature ranges from 14 to 31⁰C, colour of the water was clear to brownish green, transparency ranges 26.5-34 cm , Total dissolved solids 70-179 mg/l. Salinity 0.0 and pH 7.0-7.97. The above Physical parameters of the water were found within the permissible limit for fish culture (see Table-I). The electrical conductivity, Dissolved oxygen, Carbon dioxide, Alkalinity and Chemical oxygen demand were found in coal quarry water 140 to 332 μ /cm, 7.6 to 9.2 ppm, 0 to 18 ppm, 50 to 72 ppm and 66 to 85 ppm. The quantitative values of plankton were ranges from 0.2-0.3 ml/100 liter of water and majority of the plankton were found in phytoplankton group (see Table-II). The chemical parameters were found also in permissible range for fish culture except the alkalinity which was found lower. Plankton concentration was also very low. The preferred food of fishes is zooplankton which population is less in the water whereas due to presence of phytoplankton population the oxygen concentration is in the favorable range (see Table-III)

The human body needs friendly trace heavy metals but there are 12 poisonous heavy metals such as lead, Mercury, Aluminum, Arsenic, Cadmium, Nickel,

Chromium etc. that acts as poisonous interference to the enzyme systems and metabolism of the body.

Heavy metals are at least five times denser than water, stable and bio accumulative. Most of the heavy metals have no beneficial functions to the body and can be highly toxic. They are taken into the body by inhalation, ingestion and skin absorption. If they enter and accumulate in body tissue faster than the body detoxification pathways can dispose of them a gradual build up of these toxins will occur. High concentration exposure is not necessary to produce toxicity in the body tissue and overtime can reach toxic concentration levels (Khalid *et al.*, 1978). Mining, chemical weathering of rocks and soil are the major source of the heavy metals.

Fish is often at the top of the aquatic food chain and may concentrate large amount of these metals from the surrounding areas. Study showed that fish accumulates these heavy metals from surrounding water bodies thereby leaving a health risk if fish taken as food (Proti, 1989; Prusty, 1984).

The heavy metals i.e. iron, cobalt, nickel, copper, zinc, manganese, cadmium, lead and mercury were present in sediment, water, plankton and fish muscle. The abundance order of metals were Fe > Zn > Pb > Mn > Cu > Ni > Co > Cd > Hg in sediment and Fe > Zn > Mn > Cu > Pb > Ni > Cd > Co > Hg in water, Zn > Pb > Cu > Ni > Fe. Mn > Pb > Co > Hg in plankton and Fe > Zn > Mn > Pb > Ni > Cu > Co > Hg > Cd in fish muscle. The content of heavy metals was found higher in sediment followed by water, fish muscle and plankton. (see Table-IV)

It has been found by some worker that concentration of lead, mercury and cadmium are more in the fish than the surrounding area that is due to the bioaccumulation of the heavy metals, it is not found in the present work may be due to fish caught for analysis was young and accumulation depends on the feeding habit and age of the fish (Epko, K.E *et al.*, 2008). Under acidic conditions the free divalent ions of many metals may be absorbed by fish gills directly from the water (Merlini & Pozzi 1997). The Cd concentration increases gradually as weight and length of the fish increases. (P. Raja, *et al.* 2009). In the present work the Cd accumulation in fish was found less may be due to age of the fish and alkaline medium of the water. A little alkaline water (pH 8-8.5) is preferred for fish culture. Many workers has analyzed the different soil, water and plankton & fish for heavy metal and compared the findings with FAO recommended permissible level (FAO 1983) state committee of Russian Federation for Fishery, 1983 & WHO recommendations (WHO 1971)

The ranges of heavy metal varied in different quarries (see Table-IV) may be due to the condition of surrounding, flushing frequency and age of the coal quarries, because as the age of quarries increases the organic matter deposition increases which may bind the heavy metals and also get submerged in the sediment and get locked so it will be less available in the water.

There is no clear guideline of permissible limit of heavy metals in the fish culture water (BIS Surface water quality standard as per IS: 2296). In the present finding the heavy metals found in water is more than the upper limits for continuous exposure and /or tolerance range suggested in water quality criteria for Aquaculture hatcheries or production facilities (Mahapatra *et al.* 2000) but within the permissible limit of the drinking water (BIS standard IS 2296).

It is important to note that some coal quarries has very low concentration of heavy metals may be due to their age, heavy flushing due to rain water and inflow of organic matter in the water bodies.

From the above piece of work it may be concluded that the Physico-chemical and biological parameters of water is favourable for fish culture except the alkalinity and plankton concentration which may be improved by application of cattle dung and lime treatment.

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