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Fish culture in abandoned coal void of Jharkhand

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Abstract
Opencast mining is a common practice, after the termination of the mining activities, a mine pit is developed filled up with water. The Physico-chemical parameters of mine water have been analysed in view for the development of fish culture. The necessary measures were taken to make the water conducive for fish culture. The Physicochemical parameters were studied on monthly intervals and sample netting was done to assess the average growth of the fish. It was found that cattle manure's application improved the production of fish food, and the fish grows up to 1.5kg in eighteen months. The growth of Rohu and Mrigal was not satisfactory may be due to the desired food. The use of a submersible pump aerator has increased the dissolved oxygen concentration in different depths of the void. The coal void may be developed for fish culture by simple modification i.e., flooding with surface water, which will improve the water quality, submersible pump aerator, and application of organic and inorganic manures as per need.

Keywords: coal void, physico-chemical parameters, fish culture, submersible pump aerator

Introduction

Open-cut mining operations have become common over the last few decades in India, as a method of extracting commercially useful ore found near the surface. Since backfilling is commonly unfeasible practically or economically, an open-pit after completion of extraction operations is left. After mine operations are discontinued, and dewatering ceases, most of those that extend below the natural groundwater table, fill by the inflow of groundwater, direct rainfall, and runoff from adjacent drainage basins and the void catchment.

These large coal voids differ from the natural lake in higher relative depth. The relative depth is the relationship between the maximum extent of the water body and the mean diameter of the area. A typical natural lake has a relative depth of less than 2 - 5%, but this coal void has a relative depth between 10-40% (Doyle, 1999) [5]. It causes coal void easily to stratified with the significant changes in chemical characteristics of water with depth. The present study to study the physicochemical and biological parameters of selected coal void of Saunda coal colliery of Ramgarh district of Jharkhand (India). The findings were compared with the natural water and manmade ponds to the changes in the physicochemical parameters. Certain activities have to be done before stocking the water body with fish seed. The most important is the dissolved oxygen concentration and the development of the natural food of the fishes. To increase the production of natural food the application of inorganic and organic manure is essential. These fisheries' activities and changes in physicochemical parameters and growth of fishes have been studied.

Materials and Methods

Two coal void, namely Sangam and Saunda has been selected for the study. The Sangam coal void is under Saunda Colliery, Bhurkunda, Ramgarh district, of Jharkhand (India) was selected, which is 1000m long, 300 m wide, water depth about 44m and freeboard 15m. It is undrainable, and the primary source of water is sky feeding and runoff from nearby colonies. The coal void is abandoned since 1995. The other coal void is Saunda coal void, almost square shape of area 10ha of depth 67m. The periphery is covered with the natural vegetation, and water is used for fire fighting in the nearby areas. This void has a functional catchment area.

The Physicochemical parameters of the two voids were analysed as per APHA (2005) [2]. The parameters studied are Temperature, pH, Conductivity, TDS, DO, CO2, BOD, Nitrate, Ammonical nitrogen, Phosphate and Organic carbon. The water samples were collected in sterilized bottles from the project site with a 0.5-meter depth (surface water). The samples were collected from different depths with Kemmerer water sampler. The water parameters of the coal void were compared with the natural lake (Patratu Dam). The Indian major carps (*Catla catla*, *Labeo rohita*, *Crihinus mrigala*) were stocked, and growth was recorded on an average basis, making sample netting through gill net.

Fig 1: satellite view of project site

Results and Discussions

The physicochemical parameters are important and influenced by natural and manmade activities. It also depends on the depth, surrounding area, and runoff from the catchment area.

Temperature

There was a temperature (^{0}C) difference in the coal void and Patratu Dam at different depths. In Saunda it was 21.6 -22.6, Sangam 21.6 - 26.4 and in Patratu 20-29^{0}C. It has been reported that the temperature differences between the epilimnion and hypolimnion often reach 7^{0}C (Sugunan 1995). The temperature variation was more in Patratu Dam in comparison to the coal voids.

pH

The pH ranged in coal void from 6.8 – 8.8, which falls under the ideal range for fish culture (Boyd 1998) [3].

Conductivity and Total Dissolved solids

Conductivity is dependent on water temperature and TDS (Chesapeake Bay Program, 2012) [4]. Water flow and water level changes also contribute to conductivity. Water temperature causes to fluctuate the conductivity; besides this, its direct effect to conductivity it also influences the water density (Fondriest 2014) [6]. which leads to stratification, the stratified water has different conductivity at different depth of water.

The Conductivity and Total Dissolved solids were more in coal voids. The conductivity ranges from 156 -1726 µmohs. The conductivity of the fish pond and natural reservoir was within the permissible limit of 164 µmohs, whereas in Sangam coal void, it was 1561 and 553 µmohs in Saunda. The conductivity was more in Sangam in comparison to Saunda. It may be due to wastewater coming from the nearby colony. The TDS in the pond and reservoir range 136 -139 mg/l, whereas in the coal void 468 – 1258 mg/l, which is more than the ideal range. The total dissolved solids are more in Sangam than Saunda. This may be due to poor flushing and runoff, high evaporation, low rainfall, small groundwater inflows (Subba Rao, and.Biswas 2011) [13], and low organic matter in the bottom.

It is reported by the villagers that the fish meat is not very juicy from Sangam void as compared to Saunda,it may be due to total dissolved solids. Dissolved solids are important to aquatic life by keeping cell density balanced (Southard 2006) [12]. In low TDS water, water will flow into an organism's cells, causing them to swell. In water with a very high TDS concentration, cells will shrink. These changes can affect an organism's ability to move in a water column, causing it to float or sink beyond its normal range. The total dissolved solids and conductivity is high in Sangam, so naturally, the water from the cell will move outside; as a result, the cell will shrink.

Dissolved oxygen

Dissolved oxygen is an important criterion for the growth of aquatic organisms, especially the fishes. The desirable range of oxygen is >5 mg/l, and below that, fish will be in stress (Boyd1998) [3]. The dissolved oxygen ranges from 8.8 to 14.4 mg/l, in the reservoir, was within the ideal ranges for fish growth, but in coal void, it was 4.8 – 5.4 mg/l, which is just to the margin of the permissible range. The dissolved oxygen varied drastically in the different depth of the coal void. In Sangam the dissolved oxygen saturation level was ranged 35.81 – 116.4%, in Saunda 26.7-95.23%, and in Patratu Dam 31.67-125.65 %. The reason for the low saturation level may in coal void be due to the poor phytoplankton concentration in it. There is dissolved oxygen stratification, leading to drastic changes in dissolved oxygen concentration at different depths. The dissolved oxygen stratification in the coal void is due to the high relative depth, and there is no mixing of water.

Wind prevailing during the summer season can disturb only the upper Epilimnetic layer up to 9 m. while the inflowing flood waters break the thermocline, the strong monsoon winds up to 11km/hr help the water circulation (Ramkrishniah, M and Sarkar 1982). The oxygen stratification reduces the living space for the fish and also affects the growth; for increasing the dissolved

Oxygen concentration in the deeper layer, different types of aerators (splash and paddle aerator) were tried; it has no much effect in the deeper zone. A submersible pump aerator was tried and found more suitable. In this method a submersible pump of 2 hp was fixed at a depth of 90ft and hang by the help of floats. A nozzle was fitted in the mouth, so the water sprinkles up to 20 ft in the air. The water is circulated from 90 ft deep to surface. It has increased the dissolved oxygen in the water. It has been found that the dissolved level of oxygen has increased at different depth after four hours of operation (Table: 2).

Fig 2

Free carbon dioxide

The free carbon dioxide is the product of living organisms and also used by the phytoplankton for photosynthesis during day time; it becomes more harmful when the dissolved oxygen is less and fishes are under stress. The free carbon dioxide concentration in the selected water bodies ranges from 4.4 to 13.2, depending upon aquatic animals available in the water bodies. The ranges of free carbon dioxide are as per for fish culture in coal void.

Alkalinity

Alkalinity is the acid-neutralizing capacity of the water, and it is due to the carbonate and bicarbonate available in the water. It is reported that higher alkalinity lowers the pH fluctuation in water and increased biological activity (Singh, 1988). The alkalinity ranges from 26 – 216 are within ideal ranges. Alkalinity has an indirect effect on Primary Productivity or Phytoplankton growth. In low alkalinity, certain nutrients are unavailable to aquatic plant life. Chloride ranges 11 – 60ppm and found within the permissible range.

Hardness

The hardness of water reflects the nature of geological formations on which it has been made. Hardness is caused by divalent cat-ions; such ions are capable of reacting with soap to form a precipitate, and with certain anions present in the water, to form scales. Calcium and magnesium, which are the major causing agents of hardness, play not only an osmotically active role in the life of fish but also act as key nutrients for photosynthetic life. Excess amount of calcium in water is also not a healthy sign. Its presence beyond certain limits not only creates problems for human life and industry but also to fish as well. Its limiting effects in terms of growth and survival greatly vary with species, age, physiological state of fish, and environmental conditions. Boyd (1981) [16]. and Jhingran (1982) [17]. having the view that water containing lower values of hardness (20 mg/L), affect the production and may need liming and calcium fertilizers. Piper *et al*. (1983) had the opinion that fish grow well over a wide range of alkalinities and hardness, but values of 120 to 400 ppm are optimum. Abdul *et al*. (2004) [1]. also observed similar results with Rohu which grown better in hardness up to 450 ppm. The hardness was more than the permissible limit for fish culture in coal void Maximum was recorded in Sangam (796). The excess hardness due to calcium influences the permeability of the gill membrane disturbing the normal osmoregulation and hampers the growth of the fish. The higher hardness level attributed to higher photosynthetic activity. Higher photosynthetic activities are known to cause the release of carboxyl (OH-) group in fish ponds, which plays an important role in the binding of Calcium (Ca) with the carbonate group (CO_3) to form $CaCO_3$.

Chemical Oxygen demand

The Chemical Oxygen demand ranges from 188 to 51.5 mg/l in the selected water bodies. It is more in the manure-based fish culture pond than coal void water. Whereas in one of the coal void i.e. sangam it is higher (128) than the other one (24). It is interesting that all coal voids have not the same COD, it depends on the nature of the catchment area, flushing, and age of the coal void (Singh, 2014)

Biological oxygen demand

Biological oxygen demand represents the organic matter of the water. The sample has>5mg/l of BOD is considered enriched with organic matter (Boyd 1998) [3]. The Biochemical oxygen demand (BOD) is in the range of 1.48 to 2.0 mg/L, and it is dependent on the population of the planktonic community and other microbes. It is within the range of tolerance that created the water suitable for the survival of many aquatic organisms.

Nitrate

Nitrate concentration is usually quite low in aquaculture ponds, especially when water temperatures are warm, and plants are actively growing, plant growth removes ammonia from the water, thereby limiting the substrate levels for nitrification (Boyd 1998) [3]. Nitrate-nitrogen (1.1 – 1.98 mg/L), and ammonia-nitrogen (0.182-0.297 mg/L) was within the limit and suitable for aquaculture.

Phosphate

Phosphate was found high in Sangam (2.0 mg/l) in comparison to Patratu (1.4 mg/l) and low in Saunda (0.7 mg/l).

Organic carbon

Organic carbon in water was at par to Patratu Dam (5 mg/l), but less in Saunda (2.8ppm), it shows that Sangam coal void is more productive than Saunda.

Fish growth in coal void

The fingerling of Indian major carps (Catla catla, Labeo rohita, Crihinus mrigala) was stocked the void, and the growth was studied monthly. The data revealed that the catla catla grown about 1.5 kg in 14 month culture period. The growth of Labeo rohita and Cirrihinus mrigala was not found very satisfactory. The poor growth of Labeo rohita and Crihinus mrigala may be due to lack of desired food. The labeo is column feeder and needs on periphyton as preferred feed the coal void ha steep profound, i.e, lack of any substratum for the growth of periphyton. The mrigal is the bottom feeder, and the selected coal void do not has enriched bottom biota, which is the preferred food of mrigal. The other possibility is that the void is very deep, and there is inadequate oxygen in the bottom, so the fish cannot move in the bottom. Among all the three fishes reared in coal void, the growth of catla is better.

Fig 3

Table 1: Physico-chemical parameters of mine water before and after the Fisheries activities

Sl.no	Parameters	Sangam				Saunda				Patratu		
		Before fisheries activity	After fisheries activity			Before fisheries activity	After fisheries activity					
			Range	Annual mean	S.D		Range	Annual mean	S.D	Range	Annual mean	S.D
1	pH	6.9	6.8-8.0	7.3	0.42	7.9	7.8-8.8	8.2	0.45	7.6-8.9	8.36	0.35
2	Conductivity	1446	1401-1726	1561	96.0	538	516-639	553	43.7	156-204	164.5	15.18
3	TDS	1258	1122-1456	1312.8	97.7	468	415-469	453.2	20.03	136.19	145.12	19.0
4	Dissolved oxygen	5.4	3.6-12.4	6.75	2.5	4.8	4.8-10.8	7.2	2.16	8.8-14.4	11	15
5	Free CO2	13.2	0-17.6	11	5.71	8.8	0-11	6.16	5.09	0-4.4	0.88	1.5
6	Alkalinity	66	48-136	109	25.1	216	120-216	151	35.06	32-92	72	18
7	Chloride	60	22-31	28.25	4.38	28	22-31	27.4	2.93	8.5-11	10.06	1.21
8	Total hardness	796	796-900	860	31.31	260	244-264	256	6.69	72-104	85	10.72
9	COD	128	0-96	42.5	30.52	24	4-64	30.4	19.69	0-64	18	21.81
10	BOD	3.4	1.4-2.4	2	0.6	2.4	1.0-2.4	1.48	0.49	1.0-2.8	1.8	0.65
11	NO_3	2	0.24-2.9	1.1	0.91	2.4	0.6-3.8	1.98	1.17	0.78-1.7	1.25	0.32
12	Ammonium Nitrogen	0.25	0.05-0.37	0.297	0.12	0.24	0—0.47	0.182	0.16	0-1.1	0.411	0.317
13	PO_4	0.4	0.2-1.4	2.0	0.8	0.52	0-2.0	0.7	0.79	0-2.0	1.4	1.03
14	OC	2.4	0-10.4	5.27	3.63	5.4	0—5.4	2.8	2..0	0-11	5.71	3.05
15	Phyto plankton no./l	60		178		40		165				
	Zoo plankton, no./l	28		161		44		148				

Table 2: Dissolved oxygen concentration at different depth.

Depth (ft)	Dissolved Oxygen (mg/l)		
	Saunda	Sangam	Patratu
Surface	8.0±2.2 (95.23)	9.2±2.87(116.4)	9.6 (125.65)
10	7.3±2.2(86.9)	4.9±1.86(61.25)	9.2(113.4)
20	5.3±0.65(63.0)	4.6±1.65(56.0)	8.2(97.85)
30	4.8±0.32(57.1)	4.1±1.22(49.39)	7.49(86.75)
40	4.5±0.18(52.9)	3.9±1.11(46.9)	5.6(65.11)
50	3.9±0.49(45.8)	3.6±1.03(42.85)	4(46.51)
60	2.9±0.99(33.72)	3.6±0.92(42.85)	4(45.66)
70	2.4±1.17(27.9)	3.4±0.79(40.0)	4(45.24)

80	2.4±1.17(27.9)	3.2±0.82(37.2)	3.6(40.72)
90	2.3±1.05(26.7)	3.08±0.66(35.81)	2.8(31.67)

Table 3: Dissolved oxygen at different depth before and after aeration.

Depth	D.O Before Aeration	D.O After Aeration	Depth	D.O Before Aeration	D.O After Aeration
Surface	8.4	10.4	60 feet	4.4	4.8
10 feet	6.8	9.6	70 feet	4.0	4.8
20 feet	6.8	6.8	80 feet	4.0	4.8
30 feet	4.4	6.4	90 feet	4.0	4.8
40 feet	4.4	5.2			
50 feet	4.4	5.2			

Conclusion
Coal mining also has socio-economic impacts. These include displacement and unemployment, child labour, and accidents. The whole mine area is not suitable for agriculture due to lack of topsoil, and as a result, the livestock also doesn't develop due to lack of grazing ground. The number of large water bodies is available as mine water, which is generally no commercial use. By little modification and by applying manures and aerators, these water bodies can be brought under fish culture. The catla fish may be given more importance due to its fast growth. If all the available water bodies bought under fish culture, it will improve the displaced persons' employment and income.

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