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Economic Pisciculture on Mine Closure of Quarries

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***Abstract*:- Gradually, many deep quarries around the world are reaching an economic cut-off ratio and may be closed in near future. Mine Closure Plan usually implies filling up for agriculture, but filling materials are not available. Abandoned waterlogged quarries can be utilized commercially for fisheries by the original land owners. Global fish production is 178m mt and the Global number of fishers and fish farmers is 59.5m. Grants can be obtained from Central and now state fisheries departments. The author as General Manager (Environment) in Eastern Coalfields Ltd started in most of the water-logged quarries of ECL with no cost by the company and satisfactorily continued earning profits.**

Keywords: Cut-off ratio; Mine closure; Water-logged quarries; Fisheries; Aquaculture; Govt. Grants

1 INTRODUCTION

Across the world, fisheries provide direct employment for around 38.982 million people (Food and Agriculture Organization [FAO], 2020). From the perspective of governments, mine closure presents a complex mixture of environmental, social, economic, and development issues that the government must have ensured that

(a) The industry has adequately recognized and prepared for over the life of the mining enterprise and
(b) that the closure plan is carried out to the satisfaction of the communities involved, other major stakeholders, and government at all levels.

Governments are now coming to realize that they have the most direct responsibility for defining and ensuring comprehensive mine closure within the broader context of the issues of "social/economic equality" and "sustainable development". This recognition of the broader context of mine closure has greatly expanded the scope of government responsibilities and needed actions [1]. Mine closures have major impacts across the broad spectrum of all groups.

The Central Government vide Notification No. GSR 329 (E) dated 10.04.2003 and No. GSR 330 (E) dated 10.04.2003 amended the Mineral Concession Rules, 1960 and Mineral Conservation and Development Rules, 1988 respectively. As per these amendments, all the existing mining lessees are required to submit the "Progressive Mine Closure Plan" along with prescribed financial sureties within 180 days from the date of notification.

2. EXISTING SCENARIO

Mine Closure Plan (MCP), shall be incorporated in the Project Report for a new mine. The Mine Closure Plan (progressive and final) shall be approved along with the approval of the Mining Plan/ Feasibility Report / Project Report as applicable. Four copies of MCP of all names covered are to be submitted to the Ministry of Coal within the timeframe.

Further, the mining lessee is required to submit "Final Mines Closure Plan" one year prior to the proposed closure of the mine. In the notification it has been enumerated that the "Progressive Closure Plan" and "Final Closure Plan" should be in the format and as per the guidelines issued by the Indian Bureau of Mines. Mine closure encompasses rehabilitation process as an ongoing program designed to restore physical, chemical and biological quality disturbed by the mining to a level acceptable to all concerned. It must aim at leaving the area in such a way that rehabilitation does not become a burden to the society after mining operation is over. It must also aim to create as self-sustained ecosystem. According to Circular No. 55011 -O l -20OH-CPAM of Government of India, Ministry of Coal, Shastri Bhavan, New Delhi, the I1 January 2012, Guidelines for preparation of Mine Closure Plan have been prescribed.

Each quarry filling from external sources would cost many crores of Rupees as filling materials had to be transported from elsewhere. Western countries prefer marine fishes but in India, freshwater fishes are liked as a source of tasty low Cholesterol protein and fetch high price. Fisheries and Aquaculture constitute an important economic activity, [4] with a vast potential for sustainably harvesting a wide variety of inland and marine fisheries resources in the country. National Fish Development Board (NFDB), with the guidance of the Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, has been playing a vital role in the enhancement of fish production and productivity in the country and in coordinating fisheries development in an integrated and holistic manner. NFDB has been emphasizing culture-based capture fisheries, intensive aquaculture, and knowledge-based farming. In India, the Ministry of Fisheries, Animal Husbandry & Dairying, came into existence with Cabinet Secretariat's Notification F.No.1/21/21/2018-Cab dated 05.02.2019. Small-scale fisheries are estimated to account for more than 90 per cent of fishers and fish workers, the vast majority of which are located in developing countries.

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3. OPENCAST MINING

As a quarry goes deeper, water seepage increases going below the local ground water table. In order to continue production, regular pumping is done from the deep sump draining water out of the mining area. Production continues with overburden removal and water pumping out of the quarry. A quarry continues to produce, as long as the economic cut-off ratio of overburden to coal is reached. Backfilling materials for mine closure involve the re-handling of overburden and is progressively done [3]. But, in quarries with thick seams, backfilling materials are not available. Usually, after the quarry is abandoned, it gets filled up with water and can provide opportunities for the development of aquaculture and fisheries [15]. The lease of the mining land goes back to the owner, and he can profitably go for the fishery, whose demand is growing as a beneficial protein diet.

The development of existing open-pit coal mines is characterized by a further deterioration in the mining environment associated with the transition of mining operations to deep horizons, the increase in the stripping ratios, the limited working space of coal mines, as well as the depreciation and the obsolescence of equipment, and the increased damage to the environment [2]. One of the most promising areas for increasing open mining efficiency is the use of high overburden strips, including those based on the stripping system with overburden transport.

Many end uses have been realized:[12] passive and active recreation, nature conservation, fishery and aquaculture, drinking and industrial water storage, greenhouse carbon fixation, flood protection, waterway remediation, disposal of mine and other waste, etc. Quarry lakes from the countries where there was a greater knowledge base as shown in Table 1. (Courtesy-Mine Lakes Consulting, Australia). Fish types found in Australian pit lakes are - Pike, Essos, Lucius, Zander Sander Lucioperca, Wels, Catfish Silures, Glamis, Perch etc.

Out of some 80 minerals, including minor ores, being mined in India, around 70 of them are extracted by the small-scale sector. However, it is not easy to group these mines. In many mines, production is as low as tens of tonnes per day or even less, while some mines have a daily production of 150 to 200 tonnes. Investment and productivity in these mines also vary widely. While some of the mines are operated manually, some are considerably mechanized. Resettlement and rehabilitation processes for mining displaced people have left much to be desired.

114 coal projects with a sanctioned capacity of 836.48 mt/y (million tonnes per year) and a sanctioned capital of Rs 1,19,580.62 crore are in different stages of implementation out of which 75 projects are on schedule and 39 projects are delayed," Coal India Ltd (CIL) said in its report. The increasing trend of opencast production of coal is shown in Table 1.

TABLE 1: INCREASING TREND OF INDIAN COAL QUARRY PRODUCTION

Production of coal and lignite	**Production (Million tonne)**	**% of total production**
2005-06	437	85
2006-07	461	86
2007-08	490	87
2008-09	524	88
2009-10	566	89
2010-11	569	89
2011-12	581	90
2012-13	602	90
2013-14	609	91
2014-15	660	92

All India opencast coal production in 2019-20 was 690.208 MT or around 94% and underground production of 40.666MT and in 2020-21 was 684.862 MT or around 95% and 31.222 MT respectively. The reserve of coal as of now in India is 326 Billion Tonnes, mostly in greater depth and opencast mining may not be economic. The sustainable development of coal companies should strive to reduce the effects of mining by suitable mitigative measures. About 38 mines of major minerals have underground mining operations which is only 2.6% of the total number of producing mines for minerals.

Figure 1 shows the large opencast coal mines of India. These are likely to close in a few years and can be usefully be handed over to the original land owners for earning through fisheries.

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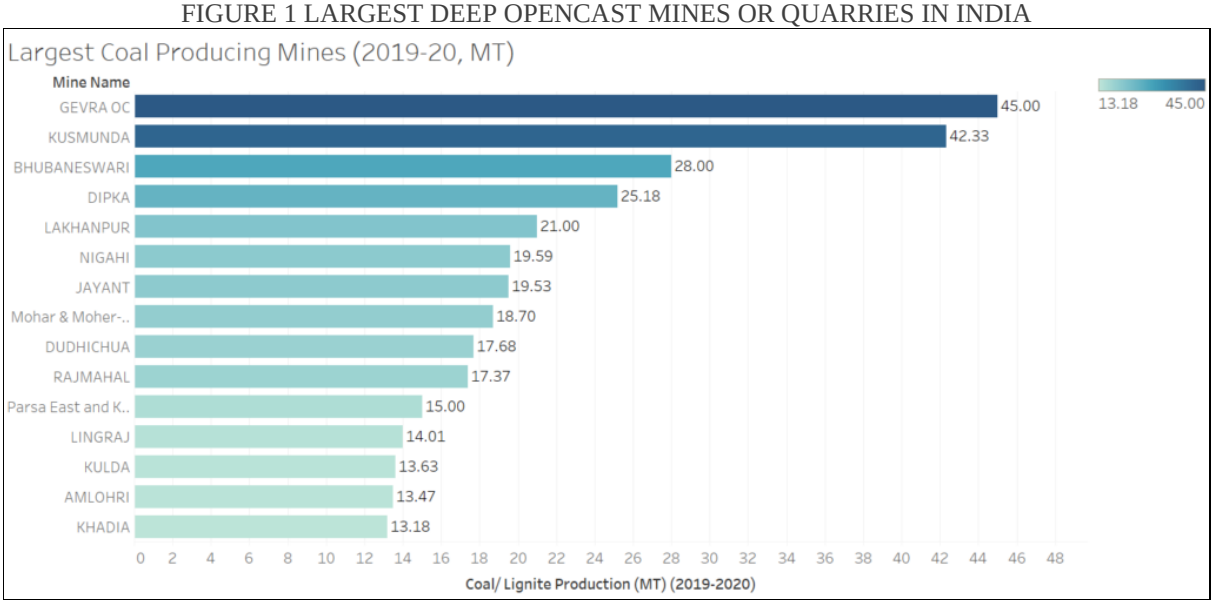
FIGURE 1 LARGEST DEEP OPENCAST MINES OR QUARRIES IN INDIA



4. PAST EXPERIENCE

The author was posted as General Manager (Env), ECL in a very crucial situation in 1996. From 1995, trade unions operating in ECL demanded that all the abandoned quarries have to be filled up. Many demonstrations were being held. I held several meetings with the trade union leaders and explained to them that around 50 abandoned quarries by erstwhile owners were water-logged. The lease after closure by a mine owner and lessee goes back to the original land owners. So, the responsibility to fill up abandoned quarries are with the land owners. Tree plantations had been done on whatever remained on overburden dumps. ECL was a losing company and we had to find a viable solution for the benefit of the landowners, to whom the land was automatically returned after closure.

The author had contacted the WB Department of Fisheries, and they agreed to help erstwhile owners, start fisheries and training. CMD and DT were apprised and they convinced the leaders that this could be very profitable. Since 1998, fisheries were started in most of the water-logged quarries of ECL with no cost by the company and satisfactorily continuing. Each quarry filling from external sources would cost many crores of Rupees as filling materials had to be transported from elsewhere. In western countries like Germany, Eco-parks are made, as people prefer marine fish. In India, freshwater fishes are liked and poor land owners would get a lot of income from fisheries. Since 1997, fisheries were started in most of the water-logged quarries of ECL with no cost by the company and satisfactorily continuing. Some Eco-parks had been made in coal companies, around water-logged quarries, but entry fees were not being paid.

5. Government Help

Now, many deep quarries in CIL subsidiaries are reaching an economic cut-off ratio and may be closed in near future. The Ministry of Fisheries, Animal Husbandry & Dairying, came into existence with Cabinet Secretariat's Notification F.No.1/21/21/2018-Cab dated 05.02.2019. Grants and help can be obtained by mining companies from Central and now state fisheries departments as well.

Fisheries and Aquaculture constitute an important economic activity, with a vast potential for sustainably harvesting a wide variety of inland and marine fisheries resources in the country. National Fish Development Board, with the guidance of the Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying, has been playing a vital role in the enhancement of fish production and productivity in the country and in coordinating fisheries development in an integrated and holistic manner. NFDB has been emphasizing capture fisheries, aquaculture, and knowledge-based farming.

Indian NFDB has been at the forefront in implementing some of the key projects by facilitating fast-track the overall fish production and productivity. The popularization of genetically improved quality fish seeds has been the primary focused area. NFDB in coordination with its network hatcheries supplied 227 Crores spawn of improved IMC varieties to the seed growers across India during 2020-21. In Bangladesh, fisheries in Closed Waterbody like Pond have 305,025 Hectares, producing 866,049 MT of fish @2,839 Kg/Hectare. In India preferred Freshwater fishes are Bata, Biam, Bele, Bashpata, Bacha, Beda, Chewa, Chanda, Chapala, Chela, Chiring, Chital, Gutum, Kholisa, Kaikka, Mola, Phasya, Pholi, Poa, Punti, Shilong, Tapashi, Tangra, etc.

A wide range of fishery development activities viz., intensive aquaculture in ponds and tanks, culture-based capture fisheries in reservoirs, solar drying of fish, domestic marketing, deep sea fishing and tuna processing, ornamental fisheries, trout culture, artificial reefs technology upgradation and capacity building of fishermen and fish farmers are being supported [12] through the State Governments/Implementing agencies. The main kinds of fishes, prawns, lobsters and other crustaceans, molluscs, turtles, and other fishery resources can be developed in water-logged abandoned quarries. Fingerlings are liberated [13] by Fisheries Dept. in every year through Social Fisheries Scheme in the reservoirs of nearby dams. Birbhum district has 13 (thirteen) nos. of private I.M.C. Hatcheries. They are producing spawns and supply the same to the fish farmers or the local areas.

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6. DEEP WATER FISHING

Fishing in deep water, with a great deep-water structure, will help catch more and better fish. Duclos says that most of his big fish are caught 18 to 25 feet deep. Big fishes cruise up into shallower water to feed, but they like to stay close to their deep water [5]. The best chance to catch these fish is when they are looking for food. A steeper structure like rip rap and bluffs can be productive. Table 2 shows different types of use of quarry lakes in various countries recorded.

Table 2. Quarry lakes with defined pit lake end uses ($n > 1$).

Country	Wildlife	Fishery	Recreation	Source	Waste	Total
Australia	7	6	8	2	2	25
Canada	6	22	2		5	35
Czech Republic	11	7	18	11	3	50
Germany	2	2	10	0	2	16
New Zealand	2	0	1	0	0	3
Poland	13	5	0	0	1	19
Spain	0	0	1	0	2	3
USA	9	10	1	2	0	22
Total	50	52	41	15	15	

Increasing demand for fish in markets such as the EU and the United States (US) stimulated production, while new fishing technologies emerged to increase the efficiency of catch. There are two main types of trap, a permanent or semi-permanent structure placed in a bottle or pot trap and periodically lifted out of the water. The fish trap might be placed in shallow water near rocks where pikes like to lie. If placed correctly, traps can be very effective. It is usually not necessary to check the trap daily, since the fish remain alive inside the trap, relatively unhurt. Because of this, the trap also allows for the release of undersized fish as per fishing regulations. Various designs of traps as per conditions of fishing [6] are Atlantic cod pot, Basic bottle trap, Bubo trap, Fyke net, Katiska trap, Barrier net, Trabucco etc.

Eastern Coalfields Ltd. had some deep abandoned waterlogged quarries, where owners were interested in developing fisheries. Among 23 IIT institutes, IIT Kharagpur has the sole distinction of having an Agricultural & Food Engineering department, which comprises six disciplines including Fisheries in Aquaculture Engineering. ECL was interested in developing an S&T project in collaboration with IIT, Kharagpur. In 1998. Director, IIT, Kharagpur sent a team of professors of the A&FE department and inspected with the author several sites. Wire-net method of deep-water fishing with accessories was suggested and for implementation deep quarry owners were wanted as partners, but postponed for future. Table No- 4 show some uses in Australian pit lakes [4] given below.

Table 4- Recreational activities undertaken by pit lakes

Activity	Black Diamond	Lake Kepware	Stockton Lake	Other (n = 6)
Swimming	83.5	53.1	72.4	50
Kayaking/Canoeing	15.0	3.1	15.4	33
Wading	31.5	21.9	24.4	17
Boating	6.3	9.4	40.7	0
Water skiing	2.4	3.1	27.6	0
Marroning	11.0	9.4	12.2	33
Picnicking	42.5	40.6	47.2	50
Camping	20.5	9.4	30.9	33.3
Walking	7.9	9.4	2.4	0
Fishing	1.6	0.0	1.6	17
Other	7.1	28.1	11.4	0

Indonesian fish traps are typically made of water-resistant fibres such as bamboo wrapped with rings of rattan, ‘bubu’ traps have been used for centuries to catch fish in a relatively unattended manner in the waters around the Alor Archipelago. The narrow-funnel traps are lowered underwater near reef systems, and a few days later they’re pulled back to the surface, hopefully, heavy and brimming with a hearty catch. The drop shot rig is also easy to see on the electronics and it keeps the lure suspended just off the bottom. This forces the fish to come up to it so anglers take the bait.

In India, West Bengal different types of fishing gear are used according to the situation: Ghuni; Dughore; Polo; Polui; Jhuri (Basket); Tati; Ciara; Toro dung; Polui (Small); Fulkuchi; Barshi (fish hook) etc. Most of them are made of bamboo and some are made of nylon nowadays. Puntius sp and Amblyopharyn go don are caught mainly by a small mesh-sized fishing net, Puthijal. The Amphipols cuchia is caught by Fulkuchi. The small craft of coastal fishing like in Kerala, the leading fishing state can be deployed in Quarry lakes. Major marine catches include sardine and mackerel; freshwater catches are dominated by carp. Other edible species are- 1. Rawas (Indian Salmon), 2. Katla (Indian Carp), 3. Rohu (Rohu or Carp Fish), 4. Bangda (Indian Mackerel), 5. Rani (Pink Perch), 6. Surmai (King Fish/Seer Fish), 7. Pomfret, 8. Hilsa, 9. Kekda (Crab), 10. Jhinga (Prawns and Shrimps).

In India, The National Institute of Fisheries Post Harvest Technology and Training NIFPHATT, the erstwhile Integrated Fisheries Project, is devoted to the all-around development of Post-Harvest Technologies. NIFPHATT envisages the best postharvest fish utilization and consumption with the least postharvest losses and delivery of the best quality fish and fish products.

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Fishing in quarry lakes would require the use of Fishing Boats as shown in Figure 2 loaded with tools and tackles and proper types [7] of fishing nets. Endeavour is being made by the Fisheries Department to Increase fish production through various means like bringing more water bodies under scientific pisciculture, ensuring access to nutritionally balanced fish feed and high-quality fish seed/fingerlings to the fish farmers, and dissemination of scientific knowledge [13] about improved techniques of pisciculture, imparting hands-on training to farmers etc. Figure 2 shows a kind of Fishing Lures which can be used for small quarry lakes.

FIGURE 2: NOVELTY FISHING LURE CRANKBAIT

6. ADVANCED RESEARCH

The Technical Methods for a detailed explanation of the methods used by the Minderoo Foundation to produce the 2021 Global Fishing Index [9]. The Technical Methods should be read in conjunction with the Global Fishing Index Key Insights report. The American Fisheries Society (AFS) is the world's oldest and largest professional society of fishery and aquatic scientists and managers. About 7,000 members are employed by academia, industry, consulting firms, nongovernmental organizations, and federal and state/provincial agencies [8]. The reclamation and closure costing information in the EIS should be addressed in terms of financial security rather than cost to the company. Financial security costs assume bankruptcy of the operator and typically include interim operations costs, general and administrative costs, and long-term costs commonly estimated on the basis of a trust fund.

Very large and deep quarry lakes may need Fishing Trawlers and Figure 3 sows more ancillary Top water Fishing Lure

FIGURE 3: FISHING TOPWATER FISHING LURE

Post-harvest technology upgradation through adaptive research to suit the ever-increasing and fast-changing consumer needs by developing new processes, products, and packaging on a pilot scale. Dissemination of the upgraded technology is achieved through consultancy, training, popularization of products, and consumer response surveys. India provides opportunities for stakeholders to participate in fisheries management through the decentralization of management responsibilities to lower levels of authority.

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West Bengal Mandate of the Fisheries department is to increase fish production by optimum utilization of all water bodies, to create infrastructure for post-harvest management, to develop an enabling eco-system for the adoption of scientific pisciculture, to strive for socio-economic uplift of the fishermen at large and to ensure availability of fish at an affordable cost to the masses. Closed system aquaculture also makes it possible to farm alien species, such as in Malaysia and Thailand, where crab, shrimp, and lobster are raised in uniform and consistent sizes at highly competitive prices [9]. As the pits are essentially isolated from open waters, more control can be exerted on water quality, food, and system additives (e.g., prophylactics, fertilizers, etc). fish waste recycling system, wherein the material is collected and reconstituted into fish food is currently being developed by the Canada Department of Fisheries and Oceans. In Australia, some of the fish found there include trout, silver perch, and goldfish. Table 3 shows key metrics of Indian Fishery

Table 3- Key metrics of Indian Fishery

Metric	Value
Progress score	27.0 out of 100
Total reconstructed catch in 2018	4.1 million tonnes
Total reconstructed catch (1990 to 2018)	99.3 million tonnes
Sustainable stocks	78%
Overfished stocks	22%
Catch from sustainable stocks (1990 to 2018)	26%
Catch from overfished stocks (1990 to 2018)	9%
Catch from unassessed stocks (1990 to 2018)	65%
Governance capacity	Medium: Level 7 of 12

7. CONCLUSIONS

The State of World Fisheries and Aquaculture 2020: Report of FAO under UNO shows that in 2018, world aquaculture fish production reached 82.1 million tonnes. Fish farming is dominated by Asia, which has produced 89 percent of the global total in volume terms in the last 20 years. An estimated 59.51 million people were engaged (on a full-time, part-time, or occasional basis) in the primary sector of capture fisheries. Although no fish were hooked in the gills, oesophagus, or stomach, odds of mortality increased by 14.21 when fish were hooked internally, which is consistent with the position that hooks placement

Guidelines for Preparation of Mine Closure Plan as per Circular No. 55011-01-CPAM of Ministry of Coal Government of India dated 11 January 2012 should be followed for coal mining in India. Mine Closure Plan (MCP), shall be Incorporated in the Project Report /Mining Plan for a new mine. The competent authority to approve the MCP will be the authority competent to approve the Mining Plan. The companies should carry out all changes, including the amount of money to be levied to the Ministry of Coal. The mining area is restored to an acceptable level to create a self-sustained ecosystem.

The final mine closure plan as per statute shall be considered to have its approval at least nine months before the date of the proposed closure of a mine. This period of nine months is reckoned as a preparatory period for final mine closure operations. Therefore, all proposals for activities that have to be carried out after the production of minerals from the mine or mining is ceased, shall be included in the final mine closure plan. The final mine closure plan will thus be a separate document with detailed chapters as per the guidelines given. The mine closure plan will be prepared as per the guidelines given as enclosure. The guidelines include the specific activities both in the progressive mine closure plan and the final mine closure plan. India has high unemployment situation and fishery development in closed mine quarries can generate profitable vocation.

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