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Residues of Mining: A Retrospective View

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Abstract- This paper focuses on the various issues related to the coal mining in India. Coal mining contributes largely towards economic development of the nation although it has a great impact upon the human health. It also has its impact on socio-cultural aspect of the workers and people residing in and around coal mining areas. Thus a holistic approach for taking up to mining activities, keeping in mind concerns for adjoining habitats and ecosystem, is the need of the hour. This requires identification of various sites where minerals exist and various factors ranging from appropriate angle of slope of overburden dumps, safe disposal drains, and safe techniques to various silt control structures etc.

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RESIDUESOFMININGARETROSPECTIVEVIEW

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Residues of Mining: A Retrospective View

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I. Introduction

It is globally accepted that coal mining adversely affects local and global environment. Dangerous levels of air and water pollution have been recorded in coal mining areas. Mining adversely affects local environment in that it destroys vegetation, causes extensive soil erosion and alters microbial communities. Although coal mining does affect global environment through release of coal- bed methane, which is about 30 times as powerful as greenhouse gas as carbon dioxide[1]. Coal mining thus adversely impacts on air quality standards. Underground mining causes depletion of groundwater at some places, as well as subsidence etc. resulting in degradation of soil and land. Subsidence of the soil beyond permissible limits requires filling of the subsidence area. The displacement and resettlement of affected people including change in culture, heritage and related features, criminal and other illicit activities on account of sudden economic development of the area can be said to be the adverse social and cultural impact[2].

Some of the beneficial impacts of mining projects are changes in employment pattern and income opportunity, infrastructural change and community development. Development in communic-ation, transport, educational system, commerce, recreation and medical facilities etc. are some positive impacts. It is thus clear that coal mining leads to environmental damage, while economic development and self-reliance call for the increased mining activities of the available mineral resources. Though there is no alternative to the site of mining operations, options as to the location and technology of processing can really minimize the damage to the environment.

II. Sources of Data & Methodology

The methodology of the research includes collection of research materials by field study and observation methods. The present study is based on both Primary and Secondary data.

a) Primary Data

1. Field study: Field study through observation method and interrogation with Management and laborers of the several collieries.
2. Documentary facts: Collection of day-by-day recorded information from Coal Mining Authority and unpublished information materials gathered from the office of coal mines.
3. Observation of the present condition of the several collieries during field study and also observation of coal mines (underground and opencast).

b) Secondary Data

The study mainly based on secondary data, collected from various sources like Economic and Statistical Department of E.C.L headquarters for all the Colliery related data like the manpower of concerned colliery, depth of the underground mines, location of opencast mines, record of accidents, etc.

c) Study Area

One of the important coalfield in India as well as of West Bengal, namely Raniganj coalfield has been selected for research purpose. The Raniganj coal field is bounded by latitudes 23° 35° N to 23° 55° N and longitudes 86° 45° E to 87° 20° E is the most important coalfield of West Bengal (Burdwan District) lies in the Damodar valley region is surrounded by Durgapur – Asansol Industrial belt. For empirical study, another study area of Jharkhand namely, Jharia coalfield has been selected for research purpose. The Jharia coalfield is located in the Dhanbad district of Jharkhand state at a distance of 260 km from Kolkata towards Delhi. It is bounded by latitudes 23° 38° N to 23° 52° N and longitudes 86° 08° E to 86° 29° E.

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[1] See report of Prabha, J & Singh, G. 2005. "*A Reviev on Emission factor Equations for Haul Roads: The Indian Perspective*": The Indian mining and engineering Journal.

[2] See Goswami, S "*Coal Mining, Environment and Contemporary Indian Society*" published in Global Journal of Human Social Science, U.S.A (B) (Volume 13 Issue 6 Version 1.0 Year 2013)

III. Assessments of Environmental Impacts of Coal Mining in India

a) Impacts of Opencast Mines on Environment (Operational Stage)

Before going to the post mining stage, the environmental impacts of the operational stage can briefly be discussed.

i. *Air*

The air in the opencast mine including its surrounding zone is affected due to various mining operations. If effective dust suppression measures are not taken the air quality deterioration in the operational stage of an opencast mine may become appreciable. However, for environment, health and operational efficacy the dust suppression is taken care by the mine management.

ii. *Water*

The natural water system in the project area as well as its surrounding zone is affected due to various reasons like mine water discharge, erosion from dump etc.

iii. *Land*

The impact on land in the operational phase is direct and visible. The mined-out area, the overburden or reject dumps, the infrastructural built-up area all affect the land during the operational stage. Unless proper reclamation is possible by backfilling, the land impacts during the operational stage remain visible and glaring. Most of the land management can be done only in the post-mining stage. However, at present thrust is for concurrent or early backfilling and physical reclamation of the mined areas or OB dumps during the operational phase itself.

iv. *Flora and Fauna*

The flora and fauna in the forest areas face the direct impact of the mining operation. The diversion of forest land for the mines and OB dumps clearly affect the floral system in the area. The fauna in the area normally migrate because most of the coal mines in the forest area are surrounded by contiguous forests.

b) Impacts of Open Cast Mines on Environmental (Post-Mining Stage)

The following are the impacts on the environmental descriptors in the post-mining stage as can be envisaged at present.

i. *Air*

After closure of the mining operation the activities causing air pollution are minimized. The activities of reclamation and rehabilitation of the areas may generate just a meager quantity of dust. This is not likely to have any impact on the ambient air quality.

ii. *Water*

The impact on water quality after the closure of the mining operation will also get reduced appreciably. The pumping of the mine water is likely to the mine water is likely to stop due to reduced activities. The quality of mine water, even if pumping is continued for some reason will be always within the acceptable limits. The pollution due to arete dumps will also slowly reduce with improved vegetative cover on these arete dumps. The problem of acidity or alkalinity will also appreciable reduces with no exposure of fresh rock surfaces in the mined area. It is therefore stated that rehabilitation of the dumps is a must for controlling the water pollution.

iii. *Land*

Land is a major problem even in the post-mining stage. The following land uses will result upon completion of the mineral extraction.

a. Mined-out area (voids)
b. Internal dump areas
c. External dump areas
d. Infrastructural areas
e. Residential areas.

Out of the above, the residential areas may be suitable developed so that aesthetically and also environmentally they remain acceptable. However, other four post-mining land uses need proper rehabilitation so that they match with the ambient scenario and are acceptable to the society as a whole.

iv. *Flora and Fauna*

The impact on flora and fauna after completion of the mining operation would remain insignificant. However, a possible impact can always be envisaged with proper planning of the land use and proper harvesting of the water and soil resources within or near the project area. The proper rehabilitation of the mining areas and rational utilization of water and soil resources will help to enrich the growth of flora and thereby advent of the migration fauna. This could be useful post-mining scenario.

IV. Site Development and Land Use Plan

A site development and land use plan should be prepared to encompass pre-operational, operational and post-operational phases of a mine. It should clearly indicate the planned post-operational land use of the area, with details of the measures required to achieve the intended purpose. The general survey for the purpose must take into account not only the broad features of the actual or proposed mining operations, nut also the surrounding terrain conditions. The important components of this survey include:

(i) Present land use pattern of the area;
(ii) Main features of the human settlements in the area;

(iii) Characteristics of the local eco-system;
(iv) Climate of the area;

Relevant terrain information that will help in arête dumping, tailings disposal, etc., with least effects on the local land-water system, including-

(a) geo-morphological analysis (topography and drainage pattern),
(b) Geological analysis (structural features-faults, joints, fractures, etc.),
(c) Hydro-geological analysis (disposition of permeable formations, surface-ground water links, hydraulic parameters, etc.),
(d) Analysis of the natural soil and water to assess pollutant absorption capacity, and
(e) Availability and distribution of top-soil;

(v) Communication and transport facilities;
(vi) Details concerning the mining plans-

(a) Minerals to be worked,
(b) Method of working,
(c) Details of fixed plants,
(d) Nature and quantity of arêtes and disposal facilities required for them,
(e) Possibilities of subsidence and landslides,
(f) Transport facilities needed, and
(g) Services to be installed.

An action plan for minimizing the adverse environmental impact from the proposed mining activity may be prepared including rehabilitation of the mining area. The important aspects to be considered are:

a) Pre-Operational Phase

(i) Vegetation barriers should be raised along the contours in the hilly areas for the prevention of soil erosion and for arresting the mine area.
(ii) Steps should be taken to construct check dams, either of rubble or brush wood, across small gullies and streams on the ore body to contain soil area. The check dams shall be stabilized by vegetation.
(iii) The banks of streams in the mining are should be intensively vegetated to prevent the discharge of sediments into the streams.

b) Operational Phase

(i) For opencast mines, screens or banks of soil and overburden shall be constructed in the peripheral area.
(ii) Vegetation barriers shall also be constructed along the periphery of a mining area on either side of the mine/service roads and between other locations. The advantages include top-soil preservation, lessening of adverse visual impact, noise-baffling, dust suppression, etc.
(iii) Clearance of vegetation should be restricted to the minimum necessary for mining operations, and planned in advance.

c) Post-Operational Phase

Once the mining operations are over, the land should be rehabilitated for productive uses like agriculture, forestry, pasturage, recreation, wild life habitats and sanctuaries.

V. Nose Pollution in Coal Mines in India

The noise is now being recognized as a major health hazard; resulting in annoyance. Partial hearing loss and even permanent damage to the inner ear after prolonged exposure is general phenomena. The problems of underground are of special importance because of the acoustics of the confined space. The ambient noise level of the underground mining area is affected by the operation of the cutting machines, tub/conveyor movement and blasting of the coal. The movement of coaling machines and transport units-conveyor, tubs and transfer points caused audible noise which becomes disturbing underground because of the poor absorption by the walls[3].

VI. Noise Pollution Due to Mining Activities

The most note generating equipment underground are the haulage, ventilators-main, auxiliary and forcing fans, conveyor transfer points, cutting and drilling machines. The ambient noise level due to different operations in underground mines varies within 80-1040 dB (A).In a mine of Raniganj and Jharia the noise level near fan house, conveyor system shearer and road headers are reported to be within 92-93 dB (A). The values increased in many Indian mines because of poor maintenance of the machines and exceeded the permissible limit of 90 dB (A) for 8 hours per day exposure[4]. The result of a noise survey for a coal mine conducted by DGMS is summarized in the following table which indicates noise over 90 dB by the drills, breaking and crushing units and transport system underground.

Table 1 : Noise Level in Underground Coal Mines

Location of survey	Average Noise level dB (A)
Near shearer	96
Transfer point	99
Tail end belt conveyor	89
Power pack pump	91
Drive head of AFC	96

Sources: CMPDI, Survey Report, 2010

[3]Refer the report of Kumar, R, G, Singh and A, Pal .2004. "Assessment of coal and minerals related industrial activities in Korba Industrial belt of Chhattisgarh": Centre of Mining Environment, Indian School of Mines, Dhanbad

[4]See Goswami, S " *Environment Management in Mining Areas*" published in Global Journal of Human Social Science, (B) U.S.A (Volume 13 Issue 7 Version 1.0 Year 2013)

The mechanized mines have lower noise problem in comparison to the old conventional mines operational mines operating with haulage and coal cutting machines. The results show that (Table 2) covering wholly manual, partly mechanized with coal cutting machines and partly mechanized with SDL loading showed reduction in the noise level underground.

Table 2 : Noise Survey in Selected Coal Mines

Type of mine	Machine points	Noise Level	Duration of Operation
Wholly manual	Drill Tugger haulage	87dB(A) 105Db(A)	1-2 hrs 4 hrs
Mechanized with CCM cutting	CCM Drill Auxiliary fan	94Db(A) 94Db(A) 93dB(A)	1 hrs 1-2 hrs 8hrs
Mechanized loading	Drill LHD Chain conveyor	88Db(A) 98Db(A) 84Db(A)	2 hrs 4-5hrs 4-5hrs

Sources: CMPDI, Survey Report, 2010

VII. Noise Pollution Due to Blasting

The blasting in underground cause's high frequency sub audible noise measured in terms of air over pressure. The magnitude of air pressure is found to be 164 dB (1) at 30m distance reduced to 144 dB (l) at a distance of 70m. Test results of some of the sites are summarized in the following table.

Table 3 : Air Pressure Due to Blasting in Underground

Mine	Explosive type	Max, charge/delay	Total charge Max, (kg)	Air over pressure at Distance-m	Value Db(l)
Ray Bacha	P1 P5 P3	kg kg 12.5kg	10.6 kg 2.4 kg 12.5 kg	50m 70m 15m	153.8 144.5 150.1
Girmit	P5	6.4 kg	2.5 kg	30m	164.8

Sources: CMPDI, Survey Report, 2010

The total noise menace due to blasting underground is the result of the audible and sub audible noise. The sub audible noise responsible for vibration causes vibration of the surface features and in case of thin overburden cracks in surface structures. This societal reaction of Jharia Town Development Forum over blasting forced the pick mining in some of the situations. The reaction of blasting is reported in the following forms.

- Damage of old structures due to vibrations.
- Public nuisance vis-à-vis disturbance of sleep.
- Disturbance of sewerage and water supply line.

The amplitude of vibration due to blast wave is observed to be reduced with increase in the height of the building and hence drop in the level of nuisance in the upper floors. The investigation in some of the mines revealed that in case of machine cut the blasting in the lower section generated more vibration than that of the upper portion. The restriction of total charge is essential to minimize the vibration due to blasting underground. The P5 explosive generates low vibration in comparison to P3 grade of explosives[5].

The noise control measures in general are categorized in three groups: personal protective measures, engineering control measures and administrative measures. The engineering control measures are the most effective as they are based on sophisticated techniques like Retrofit approach for installation of noise control treatment on mining equipment. Designing of inherently quite mining equipment is also included in this technique which aims to control and reduce the noise emission successfully. The preferred cost effective system for the underground mining has been the personal protective system – ear muffs for the operator of the noise producing units.

VIII. Toxic Arete Treatment

Nearly 25-35% of rain water drained back to ocean through reveres and streams; the major source of potable water for local population. Except particulate impurities (coal dust/soil/clay) and bacteriological or biological impurities; the river water are normally fit for consumption. Normal filtering and disinfectants made the water acceptable and had been used in India and elsewhere. Ground water on the other hand is not fit for consumption unless treated for hardness. The quality of mine water of Jharia and Raniganj Coalfield obtained from the underground mines are summarized in the following table.

[5]See Sinha, A.K and G.K. Pradhan.1986. "Bulk handling explosive system-its application in Indian surface mines": Indian Mining Journal, 25-27.

Table 4 : Mines Water Quality

Area	Kunustoria	Effluent water(MOEF schedule-vi standard)
Project	Parasea UGP	
Qtrending	June 2009	
Sampling station	W1	
Date of sample	Mine discharge from pit no. 2	
Colour	9^{th} May 2009	
Orour	unobjectionable	unobjectionable
TSS	unobjectionable	unobjectionable
PH	44.00	100.00
Temperature °c	8.40	5.50-9.00
Oil & grease	Normal	Shall not exceed 5^0c
Total residual chlorine	<1.00	10.00
Ammonical Nitrogen	Nil	1.00
Total kjeldahi nitrogen	0.03	50.00
Free ammonia	0.76	100.00
B.O.D.	BDL	5.00
C.O.D.	-	30.00
Arsenic	40.00	250.00
Lead	<0.01	0.20
H .Chromium	<0.05	0.10
Total Chromium	0.08	0.10
Copper	0.08	2.00
Zinc	0.05	3.00
Selenium	0.02	5.00
Nickel	<0.01	0.05
Fluoride	-	3.00
Dissolved phosphate	0.46	2.00
Sulphide	-	5.00
Phenolics	0.04	2.00
Maganease	<0.001	1.00
Iron	0.22	2.00
Nitrate nitrogen	0.18	3.00

Sources: CMPDI, Survey Report, 2009

Note : *All parameters are in mg/l unless specified otherwise NA stands for not analyzed.*

The water pollution problem in the mining areas is broadly classified into the following major heads depending upon the nature of coal and dump, effluents and rock formation:

- Acid mine drainage in case of high sulfur coal
- Eutrophication and Deoxygenating due troth of algae because of sulfur.
- Heavy metal pollution

High level of dissolved solids such as bicarbonates, chlorides and sulfates of sodium calcium, magnesium, iron and manganese are introduced to water while passing through aquifuge and aquiclude made permeable due to sagging and industrial usage without treatment. This makes the water hard, unfit for drinking, other impurities in a few selected mines of Jharia and Raniganj coalfield. Low level nitrates and phosphates served as nutrients to algae; rapid growth of which caused deoxygenating of water, and lowering of dissolved oxygen. This are likely to occur when the underground water are accumulated in water pools. Use of such water for irrigation might improve production and yield of crop.

IX. Heavy Metal Pollution

Heavy metals like lead, zinc, arsenic and cadmium are detected in traces in the mine water, mainly because of leaching of aquifuge, aquiclude and igneous intrusions and effluent of oil and grease from the machines underground. The toxic substances generally in the confined state within the rock mass are exposed to dynamic setting of soil water system when they start polluting mine water. The list of the toxic elements and their impact is summarized as follows:

Table 5 : Toxic Trace Elements and their Impact

Element	Impact/Effect
As	Toxic, possibly carcinogenic
Cd	Hypertension, kidney damage & toxic to biotic
Be	Acute toxicity, possibly carcinogenic
B	Toxic to plants
Cu	Toxic to plants and algae
Fl	Cause mottled teeth
pH	Toxic (Anemia, Kidney disease, nervous disorder)
Mn	Toxic to plants

Sources: CMPDI, Survey Report, 2010

Some of these elements served as nutrient to plants and aquatic life at lower concentration. There concentration in coal mine water are normally within permitted limit and required no special treatment. The survey result of two mines of Raniganj coalfield is summarized in the following table.

Table 6 : Micro Elements in Bonjemihary & Ghanshyaam Mines

Micro elements Cmol (P+) kg	Benjemihary	Ghanshyaan
Ca	0.78	51.0
Fe	0.51	0.89
Al	0.49	0.68
Mn	0.09	0.08
Zn	11	0.14
Mo	0.02	0.02
Cu	0.02	0.005
Bu	0.02	0.02

Sources: CMPDI, Survey Report, 2010
**Results in ppm.*

The presence of a large number of trace elements in coal is attributed to species of carbonaceous swamps or contemporaneous sedimentation with holmic acids solubilizing and binding these elements. Trace elements may have come through inflowing these element might have come through inflowing ground water during calcification. The magma tic and fluid might have resulted epigenetic mineralization and enrichment of trace metals. The elements like As, Cd, Hg, Pb and Zn are the inorganic fraction of coal while Cr, Cu and Sb are present in mineral in organic form. The concentration of trace elements in Raniganj and Jharia coalfield is summarized below.

In the process of mining these elements are released or mixed to the inflowing water and ultimately to water channel.

Table 7 : Concentrations of Trace Elements in Coal

Element	Concentration (μg / g^{-1}) of trace elements in regions			
	Kunustoria	Parasia	Katras	Victoria
Antimony	1.35	-	3.5	3.33
Arsenic	14.9	4.8	6.8	16.8
Cadmium	2.89	0.2	-	0.2
Chromium	14.1	12.7	17.5	31.9
Fluorine	59.3	54.0	-	-
Lead	39.8	0.8	-	21.7
Mercury	0.21	0.07	0.42	0.22
Barium	113.8	146.0	-	21.7
Nickel	22.4	5.5	-	-

Sources: CMPDI, Survey Report, 2010

Quality of water, however, is the main casualty of the scenario when hardness of the water increases up to 700 mg/l inclusive of 300-500 mg/l permanent hardness which necessitates special treatment. The other impurities like heavy metals and oxygen balance of the underground water in most of the Indian coalfields are well within the accepted limit.

The ground movement impact on hydrosphere are manifested in the form of increased storage and charging character, lowering and disturbance of the water table, loss of streams or water pools. Some of them have improved the water availability to the flora and fauna and biomass in general and improved the environment and ecology while a few caused temporary damage to the environment and ecology with the development of the fracture planes and opening of the cracks. The positive impact of the ground movement over the hydraulic regime are however, diluted due to repeated mining of the seams one after the other. With each seam working, the cycle of negative impact are repeated, water table loaded and level of pollution increased time and again. It takes time – a couple of years again before the regime are restored to normalcy.

X. Concluding Remarks

Mining below the surface destabilizes the ground, while the process of mining particularly blasting causes vibration of the surface structures and noise generation. The transfer of the raw coal, its beneficiation and handling generates coal dust, whiles open burning of coal for steam or other usage release gaseous discharge to the surface atmosphere. The movements of coal from the pit head to the loading, or consumption points in open trucks or open wagons also add coal dust to the environment all along the routes. The air absorbing moisture from the underground workings often reduces the suspended particulate matter but the fames of explosives, methane, So2, and Oxides of carbon are added to the general body of air. The concentration of these hostile gases often creates negative impact over the surface and the population nearby. With the latest realization about the impact of these green house gasses over the ozone layer has drawn the attention of the global community and efforts are on to drain methane and put it use as a fuel. The bio - diversity and the local people are also disturbed by the mining activities though they are mostly underground.

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