Eco. Env. & Cons. 28 (February Suppl. Issue) : 2022; pp. (S387-S398)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i02s.062

Comprehensive Study on Raniganj Coalfield Area, India: A Review

Dibyendu Saha[1], Jai Prakash Keshri[2] and Nimai Chandra Saha[3]*

Department of Botany, The University of Burdwan, West Bengal, India, 713 104, W.B., India

(Received 12 July, 2021; Accepted 10 August, 2021)

ABSTRACT

Raniganj coalfield, one of the crucial mining zones in India in terms of its age and production, mostly extracts coal by surface mining method depending on the under-surface. This paper presents a review on Raniganj coalfields regarding the environment, soil, vegetation, forests, habitat diversity, water quality, water regime, aquatic ecosystems, livelihood and human health. This study shows with the help of various researches that under surface coal mining is susceptible to coal fire and land subsidence while surface mine adversely affects the water, land and ambient air. Both processes are accountable for the life of the local community in the mine adjacent regions. Contrastingly mine excavating, directly and indirectly, enhances the local economy and job opportunities but negatively affects the natural and social behaviour of the local inhabitants. Coal that meets more than 60% of energy in India nevertheless needs technologies for the extraction of coal in a cleaner and more efficient manner.

Key wards : *Ambient air, Human health, Raniganj coalfield, Surface mining, Under surface mining*

Introduction

Coal is the chief and most plentiful fossil fuel in India. Simultaneously due to expanded population growth, economic boom and a quest for enhancing the quality of life, the energy requirement is rising constantly in our country. Mining has not only satisfied the uplifting energy demand of industry but also played a significant role in the economic sustainability of the country (Chaulya and Chakraborty, 1995; Adedoyin *et al*., 2020; Ashwarya, 2020; Kumar and Majid, 2020; Paliwal *et al*., 2021). The power industry is the largest consumer of coal subsequently followed by iron, steel and cement sections in the last four decades. Other smaller consumers are textile industries including jute and jute products, fertilizer, brick and paper. Coal mining and its utilization are implemented with substantial environmental challenges as it remarkably and regularly generates inevitable effects upon the terrestrial and aquatic world (Calkins, 2008; Griffin and Hammond, 2019; Farooquee *et al.,* 2020; Giggs, 2020; Tongia *et al.,* 2020). The Raniganj coalfield was established on 31st January 1973 as a coal mining site in a chunk of Damodar basin constituting Gondwana sediments. The coalfield was possessed by various small-scale private companies which were nationalized in 1973. It is the province of coal mining and the richest coal-yielding area in India (Suttner and Dutta, 1986; Hota, 2010; Jha *et al.,* 2014; Mendhe *et al*., 2017; Kumar and Singh 2020; Srivastava *et al.,* 2020). However, in this coalfield, various mining activities release diverse harmful substances such as carbon dioxide, sulphur dioxide, nitrogen oxide additionally particulate matters of dust & ash and adversely damage the native envi-

([1] Research Scholar, [2] Professor, *[3]Vice Chancellor)

ronment as it destroys vegetation, causes comprehensive soil erosion and alters microbial communities. Under surface mining causes exhaustion of groundwater in many colliers as well as subsidence etc. resulting in the destruction of soil and land (Agarwal and Sunita, 1991; Adhikari *et al*., 2013; Goswami, 2015; Mondal *et al.,* 2020; Dhar and Dutta, 2020). In this mining area numerous mining activities, developmental projects, abandoned open cast mine pits create various livelihood but contribute toxicity into the atmosphere and it adversely affects human health (Bebbington and Williams 2008; Daozhong *et al.*, 2011; Adimalla *et al*., 2020; Otamonga and Poté, 2020; Chakraborty *et al.,* 2021). This study has critically evaluated and discussed the impact of coal mining on the Environment, Soil, Vegetation, Forests, Habitat Diversity, Water quality, Water Regime, Aquatic ecosystems, Livelihood and Human health in Raniganj coalfield, India.

Materials and Methods

The Raniganj coalfield, India, an enormous reservoir of semi-coking and coking coal is surrounded by the latitudes 23°222 to 23°522N and longitudes 86°362 to 87°302E the major portion of which is sandwiched between Damodar and Ajoy river and a little portion lies onat the south of Damodar river, west of Barakar River and north of Ajoy river. It covers an area of 443.50 km^2 (171.24 sq mi) in West Bengal and Jharkhand, India (Chatterjee and Pal 2010; Singh and Yadav 1995; Boruah *et al*., 2019).

In West Bengal, the coalfield area mainly overspreads in Paschim Bardhaman district whereas Birbhum, Bankura and Purulia districts have occupied the northern, southern and south-western edges respectively. In Jharkhand, Dhanbad and Santal Pargana districts occupied the western portion of the coalfield. In this coalfield, more than 90 % area is excavated by Eastern Coalfield Limited (ECL), a subsidiary of Coal India limited (CIL) and a small area is mined by Bharat Coking Coal Limited (BCCL), also a subsidiary of Coal India Limited (CIL) & SAIL-ISPand has total coal reserves of 49.17 billion tonnes that makes it the 2nd largest coalfield in India in terms of reserves(Murthy *et al.,* 2010; Mukhopadhyay *et al*., 2010; Mohanty *et al.,* 2018; Mandal *et al.,* 2021).

A certain keyword-based hunt methodology was applied for preparing this review so that all the papers assembled weretypically informative and indicative. Google scholar was the chosen portal and custom search was accepted for every decade 1980-1990, 1991-2000, 2001-2010 and 2011-2021. The initial search terms used were Raniganj coalfield, coal mining in Raniganj coalfield, in Raniganj coalfield

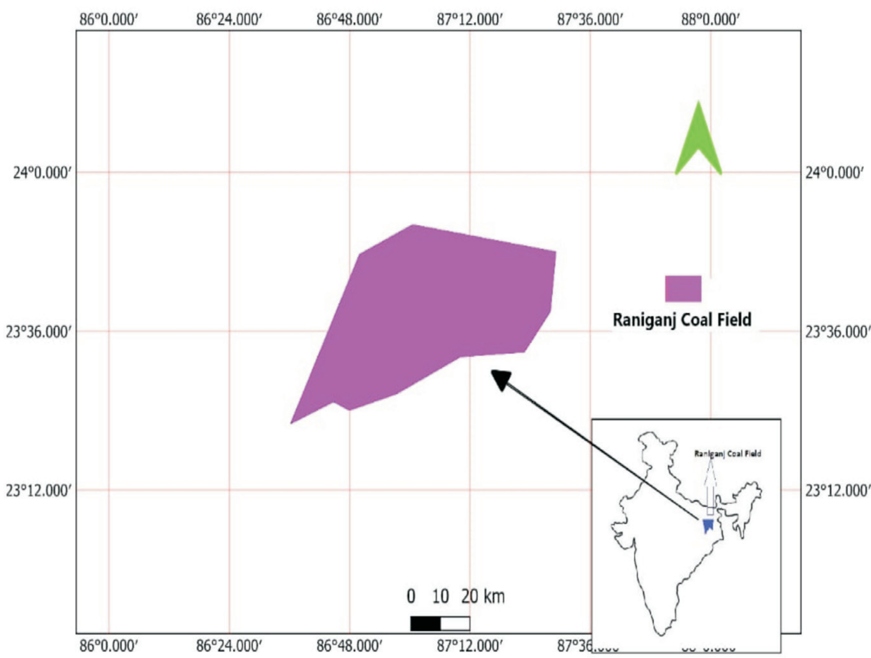

Fig. 1. GIS mapping in Raniganj coalfield, India

coal mining and its impacts and impact of coal mining in Raniganj coalfield etc. Thenthe selected papers weredownloaded from keyword search,there aftersorted and analysed. The sub references of all the papers were also considered.

Results and Discussion

Environmental pollution-an inevitable impact of mining

Mining activities of Raniganj coalfield like most of the Indian coal mines have serious impact on environment. In this coalfield, coal is mainly mined using two methods - underground and surface or opencast mining. A vast amount of waste material is generated by several mining activities. If proper care is not taken for waste disposal, mining activity will affect thesurrounding atmosphere, the water, land and ambient air and in turns the life of the local community in the adjacent regions (Bose *et al.,* 1986; Ghosh, 1987; Sengupta, 2001; Sadhu *et al.*, 2012; Goswami,

Fig. 2. Mining activities in Raniganj coalfield

Mining activity causes huge air pollution actively or passively. Pollutants like Particulate Matter, Sulphur dioxide, Nitrogen dioxide, Carbon dioxide, ash etc., are the crucial emissions during coal mining, burning of coal and operational mine fires. Coal mining also harms the environment due to the release of methane from coal bed which is nearly 30 times stronger than the greenhouse gas as carbon dioxide. Owing to dryness and lack of humidity the winter season is observed to be the riskiest among all the seasons in the year with respect to respirations of ambient air (Agarwal and Sunita, 1991; Baldauf *et al.,* 2001; Collins *et al.,* 2001; Dash *et al.*, 2020; Mondal and Mistri, 2021).

Deterioration of the quality of soil for mining activity

Continual coal mining activities in Raniganj coalfields have created acute threat to the soil quality of nearby agriculture fields and have generated a long-term effect on the vital component of the natural ecosystem of the soil. Contented heavy metals like As, Co, Cu, Be, Cr, Mn, Pb, and Ni are significantly higher in opencast mine soil, whereas Cd PAHs contents arehigher in underground mine soil (De *et al.,* 1985; Casshyap and Kumar, 1987; Das and Chakrapani, 2011; Masto *et al.,* 2015; Vishwakarma *et al.,* 2020).

Fig. 2. Soil of mining site and adjacent area in Raniganj coalfield

In this framework researchers have noticed that the range of moisture content, bulk density, electrical conductivity and pH are moderate in this mining site, where plants have normal growth, but the concentration of nitrogen, organic carbon, organic matter, and available phosphorus have been found inferior as a contrast to normal soil, thus, brought about deterioration of soil quality, hence it is found that mining soil is not suitable for plantation, vegetation or agricultural purposes. High salinity, % Na, sodium absorption ratio, residual sodium carbonate, and excess Mg that restrict its suitability for agricultural uses is reported (De and Mitra, 2002; Singh *et al.,* 2010; Yaseen *et al.,* 2012; Yaseen *et al.,* 2015; Rehman *et al.,* 2020).

Illegal coal mining activities have resulted in maturing hidden hollows, pits, shafts, rat holes, galleries, etc., that created great threat of land subsidence, fire, water flooding leading to severe degradation of the environment, health and safety issues of the local inhabitants (Hota, 2010; Bharti *et al.,* 2016; Rehman *et al.,* 2020; Srivastava *et al.,* 2020).

Adverse impact on Vegetation, Forests, Habitat Diversity

The main effects of excess mining are pollution, deforestation and imbalance of ecology. The removal of coal/minerals from nature repeatedly makes awkward nature, which adversely influences the biological system and condition. On the other hand the informal and unscientific mining serves as a veritable danger the outcomes of which results in decrease in forest cover, soil loss and decrease of all-inclusive biodiversity. These transformations causes modification in nutrition, depletion of resources and trophic interactions (Almas *et al.,* 2004; Ghose, 2004; Rai *et al*., 2010; Singh *et al*., 2011; Pawar *et al.,* 2014; Kumar *et al*., 2015; Saikat *et al.,* 2020).

Fig. 3. Forest of mines adjacent site in Raniganj coalfield

Saikat *et al.,* (2020) reported an aggregate of a maximum of 21 shrub species belonging to 17 families in this mining area and its total density was 7.6 in. The maximum noted was in *Clerodendrum infortunatum*. The densities recorded by the said researches were acceptably correlated with some of the other research findings Malakar and Gupta (2019) recorded 19 tree species where *Leucaenaleucocephala* and *Ziziphus jujube*, *Shorearobusta* were found dominant species based on their substantial values. Moreover, expansion in species richness and colonization of native species were also detected with rehabilitated ages at chronosequence sites. So their study specified that changes in soil variables are related to succession, whereas functional/structural changes in vegetation are interconnected to the accumulation of soil texture, organic matter and enhanced microbial effects. Sarma (2002, 2005) noticed a distinct trend of distribution of plants in Raniganj coalfield area and also in Meghalaya Nokrek biosphere reserve (Mishra *et al.,* 2008; Jhariya *et al*., 2012, 2016; Kumar *et al.,* 2011, 2015; Malakar and Gupta, 2019; Saikat *et al.,* 2020).

Water quality, Water Regime, Aquatic ecosystem and fields of using pit-water

Mine waters are extremely complex in nature and generally vary in composition. These are almost neutral, alkaline, moderately acidic, and exceptionally acidic in nature. The concentrations of metals, metalloids, acidity, and alkalinity, Cl”, F” and SO24 contaminated the rivers, water bodies, surface, and underground water (Rawat *et al.,* 1981; Singh 1988; Plumlee *et al.,* 1999; Nordstrom, 2011; López *et al.,* 2019). On the other hand pit lakes are formed when open cast mines pit are filled with water, either through groundwater recharge, surface water diversion, or functioning pumping. There are about 78 old opencast coal pits surrounding 260 hectares of expanse containing a total volume of 4,41,17,700 m^3 presently transformed into pit-lakes becoming a potential aquatic resource for this mine area. Different studies on limnological parameters show that mine pit water is high in conductivity, total suspended solids, total dissolved solids, biochemical oxygen demand, chemical oxygen demand, Salinity, nitrate nitrogen, sulphates, etc. At the same time, Water Quality Index (WQI) outcomes indicate that almost all the pit-lakes in Raniganj coalfield show poor to unsuitable water quality. Most of the researchers suggested that mine water of the coalfield is not satisfactory for first-hand use in drinking & domestic purposes and requires proper treatment before its utilization. The evaluation of pits’ water for irrigation uses shows that the water is good to allowable quality and can be utilized for irrigation purposes. Nevertheless, high values of salinity, SAR, RSC, % Na and Mg-hazard at certain areas restrict its acceptability for agriculture uses. (Ghosh, 1990; Tiwary and Dhar, 1994; Singh *et al.,* 2009; Singh *et al.,* 2010; Pal *et al.,* 2013; Palit *et al.,* 2014; Mondal and Palit, 2019).

Within this frame of reference in an aquatic ecosystem primary productivity is the estimation of the net yield of new biomass during a certain time by photosynthesizers which are existing at the basis of a food chain in an ecosystem. Indirectly it expressed the phytoplanktonic population and ecological condition of an aquatic ecosystem. The zooplankton community forms a vital relationship in the food chain from primary to tertiary levels in an aquatic

Fig. 4. Mine stagnant water and water body of the Raniganj coalfield

ecosystem. Fish production is also depending on zooplankton load. The diversity and number of zooplankton suggested the quality of water and ecological status of this water body. Pal *et al.,* (2013) reported that values of primary productivity were varying from 150 to 610 mg C m-3 hr-1 (average 310 ± 110 mg C m-3 hr-1) and during the post rainy seasons higher productivity values were observed. Zooplanktonic load in pit water was noticed in the range of 2.0 to 6.0 U L-1 (average 4.0 ± 1.0 U L-1) similarly higher zooplankton load was found during the monsoon seasons. Less abundance of the zooplankton load in mine pit lakes in this mines area was also reported by several workers (Canton and Ward, 1981; Canton, 1982; Slusarczyk, 2003; Chatterjee *et al*., 2008; Kosík *et al*., 2011; Palit and Kar, 2019).

Benefit of local livelihood by the coalmines

The requirement of coal has increased countrywide mining activities, which assist to enhance the prosperousness of the national capital. The extension of settlements in the coal sector was followed by rashes of relocation among workers. The settlement of Raniganj in West Bengal, in the beginning, witnessed the migration of subaltern classes' people from its adjacent districts and states. In this coalfield, especially rural regions are often affected by this composite nature of mining. The local livelihood

Fig. 4. Cultivated land and Abandoned open cast coal pit maintain the livelihood of Raniganj coalfield

experiences most by mining-induced rearrangement and land procurement. At different times different researchers from various mining sites in this coalfield find out that the rural societies are affected positively as well as negatively by the mining activities. Owing to the expansion of mining, acquisition of land has contributed monetary and job recompenses to the local land losers that directly and indirectly boost up the local economy but the job opportunities are very much restricted to the landowners. From the E.C. Ltd., monetary reimbursement has aided to increase the physical capital among the communities in this coalfield. In contrast natural and social capitals are negatively affected by the mining and associated activities (Bhengara, 1996; Das and Mishra, 2015; Banerjee and Mistri, 2019; Das, 2020; Mondal and Mistri, 2021).

Conversely, different studies on the Raniganj coalfield area explored that community's livelihood was potentially benefited by abandonedO.C.P.s. e.g. irrigation (Table 1), O.C.P.s' water is utilized for various purpose like bathing, cooking, washing clothes and also for miscellany cultivation. Several researchers' observation cited that about 10%, 60% and 90% of rich, middle-class & poor households respectively use the O.C.P'.s water for their domestic purposes. About 10% of the rich households and 60% and 80% middle-class and poor households respectively take fishes collected (Table 1) from O.C.P.s as food. 74% poor households collect fuel woods and wild fruits of the forest nearby the O.C.P.s (Table 2, Figure 1) (Samanta, 2001; Singh, 2008; Sinha *et al*., 2017; Palit and Kar, 2019; Palit and Chaudhury, 2020; Mandal *et al.*, 2021).

Impact of mining activity on Human health of coalfield area

Coal mining activity of Raniganj coalfields, a large-scale producer of coal adversely affects the human health of the mining area as the surface and underground activity – two chief processes are causing air pollution, a major reason of health hazard. In mining site, some activities like drilling, blasting, loading-unloading of materials, overburden, etc. fabricate several fine particles which remain suspended in ambient air and create respiratory diseases. Several earlier studies have specified that the air pollution due to PM is very high in the workplace of

Table 1. Cultivation of Fishes, Cereal and Vegetables after utilised of abandoned O.C.P.'s in Raniganj coalfield

Fishes		Cereal & Vegetables	
Scientific name	**Local name**	**Scientific name**	**Common name**
Channa punctatus	Lata	*Oryza sativa*	Rice
Clarias batrachus	Magur	*Allium cepa*	Onion
Oreochromis niloticus	Nilontica	*Raphanus sativus*	Radish
Labeo calbasu	Calbaus	*Daucas carota*	Carrot
Catla catla	Catla	*Solanum melongena*	Brinjal
Labeo rohita	Rui	*Brassica oleracea capitata*	Cabbage
Labeo bata	Bata	*Brassica oleracea italica*	Broccoli
Hypophthalmichthys molitrix	Silver carp	*Brassica oleracea*	Cauliflower
Cirrhinus mrigala	Mrigel	*Capsicum annuum*	Chili
Aristichthys nobilis	Bighead Carp	*Cucumis sativus*	Cucumber
Cyprinus carpio	American Rui	*Allium sativum*	Garlic
Ctenopharyngodon idella	Grass Carp	*Lycopersicon lycopersicum*	Tomato
Amblypharyngodon mola	Mourala	*Zea mays*	Sweet corn
Puntius sophore	Punti	*Solanum tuberosum*	Potato

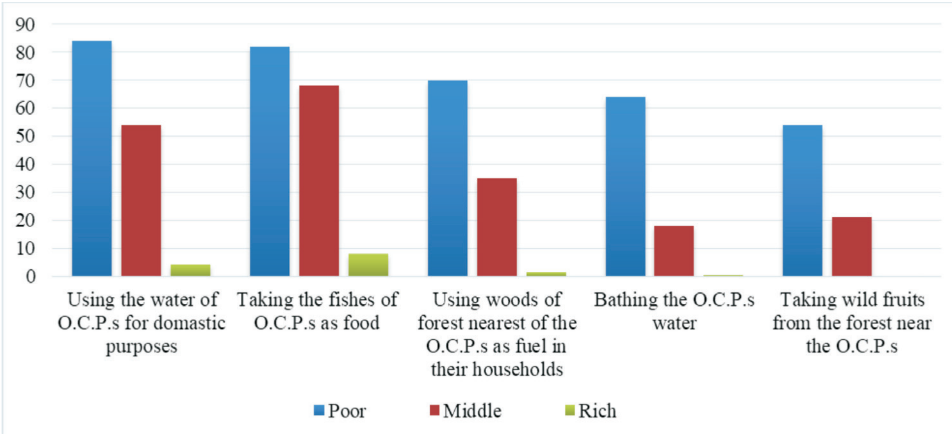

Fig. 5.% of the families from different economic classes using O.C.P.s resources for their regular needs.

Table 2. % of the families from different classes continuing their livelihoods by utilising abandoned O.C.P'.s resources.

Nourishing their liveliwood by using O.C.P.s resources	% of Livelihoods		
	Poor	Middle	Rich
Irrigating their cultivated lands	73	28	16
Fish farming	52	15	0
Drawing from selling the fuelwood collected from the nearest forest	75	0	0
Utilize the grasses nearby the O.C.P.s as the fodder for cattle	96	12	0
Utilize O.C.P.s water for their diversified cultivation	54	39	23
Drawing from wild fruits collected from the forests nearby of the O.C.P.s	31	0	0
Drawing from the visitors of the O.C.P.s by providing different servises	16	0	0

Source: Families' economic classes as described in Census India, 2011

opencast mines in Raniganj coalfield. In these circumstances, researchers sort out that all effects on human health through particulate matters (PM) are pursuing the time of subjection and quantity of particles in such type concentration. In addition, pollutants like sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon dioxide (CO_2), etc., are also the most principal emissions during coal mine fires. Due to dryness the winter season is noticed to be the most hazardous among all the seasons in the year concerning respirable ambient air (Baldauf *et al*., 2001; Chattopadhyay, 2001; Collins *et al.,* 2001; Peplow and Edmonds, 2002; Younger and Wolkersdorfer, 2004; Gautam *et al*., 2012).

In Raniganj coalfields the rate of discharge of greenhouse gas is increasing gradually (0.4% per annum) to the frightening level and has become detrimental to local residents. The air quality in the vicinity of the said coalfield, moreover in the mine's ambience, is very much negatively altered, which is judged by the yardstick of Air Quality Guideline Levels laid down by the WHO. Generally, it is noticed that the mining workers and local inhabitants are affected by breathlessness, asthma, bronchitis, chronic obstructive pulmonary disorders (COPD), black lung disease (permanent scarring of the lung), cardiovascular disorders, irritation to the eye, nose, throat, skin, diabetic, hypertension, kidney problems, liver problems, poor visibility, etc., (Schins and Borm, 1999; Goswami, 2014; Samanta, 2015; Neogi *et al*., 2018; Dash *et al.,* 2020).

Conclusion

The Raniganj Coalfields has been the lion's share source of coal in India for more than 200 years. The extractive operation undeniably has brought wealth and employment opportunities, but concurrently has led to comprehensive environmental destruction and erosion of traditional values in the community. Coalmines both opencast and underground processes brought about titanic damage to the flora, fauna, forests, hydrology, and soil biological properties of the systems. Simultaneously it severely affects human health. Across the mining area it is explored that communities' livelihood potentially gained from abandoned mine pit-lakes. At the end of the discourse the authors suggest that implementation of rigid environmental contamination control through better contamination control technology, greater and significant public awareness and sincere supervision of competent authority should be ensured to have a clean coal mining. It is also thought that solar power, wind energy, heat mining, biofuel, biogas etc. should be adopted as energy resources to reduce our dependence on coal in future.

Acknowledgement

The authors are also thankful to Head of the Department, Botany, The University of Burdwan, West Bengal for Laboratory facilities.

The authors are thankful to the respected General Manager and his office staff, Satgram area, E.C. Ltd. for their kind assistance and cooperation at the time of the study.

Conflict of interest

The authors declare no conflict of interest.

References

Adedoyin, F.F., Gumede, M.I., Bekun, F.V., Etokakpan, M.U. and Balsalobre-Lorente, D. 2020. Modelling coal rent, economic growth and CO2 emissions: does regulatory quality matter in BRICS economies?. *Science of the Total Environment*. 710 : 136284.

Adhikari, K., Sadhu, K., Chakroborty, B. and Gangopadhyay, A. 2013. Effect of mining on geochemistry of groundwater in Permo-carboniferous Gondwana coalfields: Raniganj Basin, India. *Journal of the Geological Society of India*. 82 (4) : 392-402.

Adimalla, N., Chen, J. and Qian, H. 2020. Spatial characteristics of heavy metal contamination and potential human health risk assessment of urban soils: a case study from an urban region of South India. *Ecotoxicology and Environmental Safety*. 194: 110406,10.1016/j.ecoenv.2020.110406.

Agarwal, A. and Sunita, N. 1991. Global warming in an unequal World. *International Sustainable Development.* 1: 98-104.

Almas, A.R., Bakken, L.R. and Mulder, J. 2004. Changes in tolerance of soil microbial communities in Zn and Cd contaminated soils. *Soil Biology and Biochemistry*. 36 (5) : 805-813.

Ashwarya, S. 2020. Emerging Contours of India–US Fossil Fuel Trade. *Strategic Analysis*. 44 (4): 312-331.

Baldauf, R.W., Lane, D.D. and Marote, G.A. 2001. Ambient air quality monitoring network design for assessing human health impacts from exposures to airborne contaminants. *Environmental Monitoring and Assessment*. 66 (1): 63-76.

Banerjee, R. and Mistri, B. 2019. Impact of coal mining in diversification of rural livelihoods: A case study in the Barjora colliery area of Bankura district, West Bengal. *Space and Culture, India.* 6(5): 228-240.

Bebbington, A. and Williams, M. 2008. Water and mining conflicts in Peru. *Mountain Research and Development*. 28(3) : 190-195.

Bharti, A.K., Pal, S.K., Priyam, P., Pathak, V.K., Kumar, R. and Ranjan, S.K. 2016. Detection of illegal mine voids using electrical resistivity tomography: the case-study of Raniganj coalfield (India). *Engineering Geology*. 213 : 120-132.

Bhengara, R. 1996. Coal mining displacement. *Economic and Political Weekly*. 31 (11): 647-649.

Boruah, A., Rasheed, A., Mendhe, V.A. and Ganapathi, S. 2019. Specific surface area and pore size distribution in gas shales of Raniganj Basin, India. *Journal of Petroleum Exploration and Production Technology.* 9 (2): 1041-1050.

Bose, A.K., Dalal, B.N., Mullick, P.K., Sinha, J.K. and Singh, B. 1986. Air pollution study in Mugma Ranigunj Coalfields West Bengal. *Ind. J. Air Pollution Control Assoc*. 7 : 11-18.

Calkins, M. 2008. *Materials for sustainable sites: a complete guide to the evaluation, selection, and use of sustainable construction materials.* John Wiley & Sons, 1-480.

Canton, S.P. 1982. Comparative limnology and biota of mine spoils ponds in Colorado. *Southwest Nat*. 27(1):33-42.

Canton, S.P. and Ward, J.V. 1981. Benthos and zooplankton of coal strip mine ponds in the mountains of northwestern Colorado, U.S.A. *Hydrobiologia.* 85 (1): 23-31.

Casshyap, S.M. and Kumar, A. 1987. Fluvial architecture of the Upper Permian Raniganj coal measure in the Damodar basin, Eastern India. *Sedimentary Geology.* 51 (3-4) : 181-213.

Chakraborty, B., Bera, B., Roy, S., Adhikary, P.P., Sengupta, D. and Shit, P.K. 2021. Assessment of non-carcinogenic health risk of heavy metal pollution: evidences from coal mining region of eastern India. *Environmental Science and Pollution Research.* 1-19, https://doi.org/10.1007/s11356-021-14012-3.

Chatterjee, A., Roy, R.K., Ghosh, U.C., Pramanik, T., Kabi, S.P. and Biswas, K. 2008. Fluoride in water in parts of Raniganj Coalfield, West Bengal. *Current Science*. 94 (3) : 309-311.

Chatterjee, R. and Pal, P.K. 2010. Estimation of stress magnitude and physical properties for coal seam of Rangamati area, Raniganj coalfield, India. *International Journal of Coal Geology*. 81(1): 25-36.

Chattopadhyay, A. 2001. Bardhaman Jelar Itihas O Lok

Sanskriti Talk (in Bengali): Bardhaman. 1: 46-51.

Chaudhuri, S. 2015. Soil development in 2–21 years old coalmine reclaimed spoil with trees: A case study from Sonepur-Bazari opencast project, Raniganj Coalfield, India. *Ecological Engineering*. 84: 311-324.

Chaulya, S.K. and Chakraborty, M.K. 1995. Perspective of New National Policy and Environmental Control for Mineral Sector, in G.S. Khuntia (ed.). *Proceedings of National Seminar on Status of Mineral Exploitation in India, New Delhi, India.* 114-123.

Chaulya, S.K., Chakraborty, M.K. and Singh, R.S. 2001. Air pollution modelling for a proposed limestone quarry. *Water, Air, and Soil Pollution*. 126 (1):171-191.

Collins, M.J., Williams, P.L. and McIntosh, D.L. 2001. Ambient air quality at the site of a former manufactured gas plant. *Environmental Monitoring and Assessment*. 68 (2): 137-152.

Daozhong, C., Qingli, Z., Jie, W. and Xiaozhi Z. 2011. Comparative analysis of ecological rucksack between open-pit and underground coal mine. *Energy Procedia*. 5 : 1116-1120, https://doi.org/10.1016/j.egypro.2011.03.196.

Das, N. and Mishra, N. 2015. Assessing the impact of coal mining on diversified sources of rural livelihoods: A case study in the Ib Valley coalfield area of western Odisha, India. *International Research Journal of Social Sciences*. 4(6): 83-88.

Das, S. 2020. Migrants, work, and sustenance in the coalfield of Raniganj. *Journal of Labor and Society*. 23 (3): 265-281.

Das, S.K. and Chakrapani, G.J. 2011. Assessment of trace metal toxicity in soils of Raniganj Coalfield, India. *Environ Monit Assess*. 177: 63–71, https://doi.org/10.1007/s10661-010-1618-x.

Dash, T.R., Tripathy, D.P. and Pandey, J.K. 2020. Chemical characterization of PM 10 and evaluation of health risk for the people residing around a highly mechanized opencast coal mine using FTIR spectroscopy. *Arabian Journal of Geosciences*. 13 (4):1-17, https://doi.org/10.1007/s12517-020-5167-5.

De, A.K., Sen, A.K., Karim, M.R., Irgolic, K.J., Chakraborty, D. and Stockton, R.A. 1985. Pollution profile of damodar river sediment in Raniganj-Durgapur industrial belt, West Bengal, India. *Environment International*. 11(5):453-458.

De, S. and Mitra, A.K. 2002. Reclamation of mining-generated wastelands at Alkusha-Gopalpur abandoned open cast project, Raniganj Coalfield, eastern India. *Environmental Geology.* 43(1-2):39-47.

Dhar, S.B. and Dutta, M. 2020. Changing land use pattern in the Raniganj Coal Belt and its Sustainable Management: a case study of Mangalpur Opencast Calliery. *Current World Environment.* 15 (special issue 1): 76-88.

Farooquee, N.A., Swain, M., Rajagopal, M.R. and Pattanaik, B.K. 2020. Block-2 Rural Development in India.

Gautam, S., Patra, A.K. and Prusty, B.K. 2012. Opencast mines: a subject to major concern for human health. *International Research Journal of Geology and Mining.* 2 (2): 25-31.

Ghose, A.K. 1990. Mining in 2000 AD-challenges for India. *Bulletin of the Institution of Engineers; (India)*. 39 (11): 11-12, 14.

Ghose, M.K. 2004. Effect of opencast mining on soil fertility. *Journal of Scientific and Industrial Research*. 63 (Dec.): 1006-1009.

Ghosh, R. 1987. The variation in thickness and composition of coal seams and its use in interpretation of palaeocurrents-A case study from the Raniganj Coalfield, West Bengal, India. *International Journal of Coal Geology*. 9 (2): 209-220.

Giggs, R. 2020. *Fathoms: The World in the Whale.* Simon & Schuster, 1-325.

Goswami, S. 2014. Clean Coal Initiatives in India. *European Researcher*. 8(2): 1499-1513.

Goswami, S. 2015. Impact of coal mining on environment. *European Researcher.* A (3): 185-196.

Griffin, P.W. and Hammond, G.P. 2019. Industrial energy use and carbon emissions reduction in the iron and steel sector: A UK perspective. *Applied Energy*. 249 : 109-125. https://doi.org/10.1016/j.apenergy.2019.04.148.

Hota, R.N. 2010. The Gondwana Basins of Orissa-Are they Remnants of a Palaeo-master Basin?. Unpublished, https://doi. org/10.13140/2.1, 2371.

Jha, N., Sabina, K.P., Aggarwal, N. and Mahesh, S. 2014. Late Permian palynology and depositional environment of Chintalapudi sub basin, Pranhita-Godavari basin, Andhra Pradesh, India. *Journal of Asian Earth Sciences*. 79 (Part A): 382-399.

Jhariya, M.K., Bargali, S.S., Swamy, S.L. and Kittur, B. 2012. Vegetational structure, diversity and fuel load in fire affected areas of tropical dry deciduous forests in Chhattisgarh. *Vegetos*. 25(1): 210-224.

Jhariya, M.K., Kittur, B.H. and Bargali, S.S. 2016. Assessment of herbaceous biomass: A study in Rowghat mining areas (Chhattisgarh), India. *Journal of Applied and Natural Science.* 8 (2) : 645-651.

Kosik, M., Cadkova, Z., Prikryl, I., Seda, J., Pechar, L. and Pecharova, E. 2011. Initial succession of zooplankton and zoobenthos assemblages in newly formed quarry lake medard (Sokolov, Czech Republic), In: Mine water – managing the challenges, T.R. Rüde, A. Freund and C. Wolkersdorfer (Eds.). *Proceedings of 11th International Mine Water Association Congress.* 517-521.

Kumar, A., Jhariya, M.K. and Yadav, D.K. 2015. Community characters of herbaceous species in plantation sites of coal mine. *Journal of Plant Development Science*. 7(11): 809-814.

Kumar, J.C.R. and Majid, M.A. 2020. Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. *Energ Sustain Soc*. 10 : 2 https://doi.org/10.1186/s13705-019-0232-1.

Kumar, P. and Singh, A.K. 2020. Hydro geochemistry and quality assessment of surface and sub-surface water resources in Raniganj coalfield area, Damodar Valley, India. *International Journal of Environmental Analytical Chemistry*. 1-24.

Kumar, S., Chaudhuri, S. and Maiti, S.K. 2011. Biodiversity of grasses and associated vegetation on different aged soil dumps from Sonepur Bazari OCP, Raniganj coalfield. *International Journal of Environmental Sciences*. 2 (2) : 715-722.

Kumar, S., Maiti, S.K. Kumar, P. and Singh, A.K. 2020. Hydro geochemistry and quality assessment of surface and sub-surface water resources in Raniganj coalfield area, Damodar Valley, India. *International Journal of Environmental Analytical Chemistry.* 1-24.

López, J., Reig, M., Gibert, O. and Cortina, J.L. 2019. Recovery of sulphuric acid and added value metals (Zn, Cu and rare earths) from acidic mine waters using nanofiltration membranes. *Separation and Purification Technology*. 212 (April) : 180-190.

Malakar, S. and Gupta, H. 2019. Composition and Diversity of Tree Saplings in Raniganj Coalfield of West Bengal. *International Journal of Research and Analytical Reviews*. 6 (1): 667-672.

Mandal, A., Biswas, T., Mondal, N.S., Dey, S., Patra, A., Das, S., Mondal, A.K., Dey, A.K. and Ghosh, A.R. 2021. Assessment of the nutritional quality of fish cultured in Samdihi, an open cast coalpit at the Raniganj Coal Field areas, West Bengal, India. *Lakes & Reservoirs: Research & Management*. 26(1): 3-12.

Masto, R.E., Sheik, S., Nehru, G., Selvi, V.A., George, J. and Ram, L.C. 2015. Assessment of environmental soil quality around Sonepur Bazari mine of Raniganj coalfield, India. *Solid Earth*. 6 (3): 811-821.

Mendhe, V.A., Mishra, S., Varma, A.K., Kamble, A.D., Bannerjee, M. and Sutay, T. 2017. Gas reservoir characteristics of the lower gondwanashales in Raniganj basin of eastern India. *Journal of Petroleum Science and Engineering*. 149 : 649-664.

Mishra, R.K., Upadhyay, V.P. and Mohanty, R.C. 2008. Vegetation ecology of the Similipal Biosphere reserve, Orissa, India. *Journal of Applied Ecology and Environmental Research.* 6(2): 89-99.

Mohanty, D., Chattaraj, S. and Singh, A.K. 2018. Influence of coal composition and maturity on methane storage capacity of coals of Raniganj Coalfield, India. *International Journal of Coal Geology*. 196 : 1-18.

Mondal, R. and Mistri, B. 2021. Opencast coal mining and rural livelihoods: a study of Sonepur-Bazari mine in Raniganj coalfield area, West Bengal, India. *Mineral Economics*. 1-14, https://doi.org/10.1007/s13563-021-00271-6.

Mondal, S. and Palit, D. 2019. Evaluation of water quality using water quality index of Pit Lakes, Raniganj Coal Field Area, West Bengal, India. *Research Journal of Life Sciences, Bioinformatics, Pharmaceuticals and Chemical Sciences.* 9 (11): 532-550.

Mondal, S., Palit, D. and Chattopadhyay, P. 2020. Impact of mining on tree diversity of the coal mining forest area at Raniganj coal field area of West Bengal, India. *Eco. Env. & Cons.,* 26 (August Suppl. Issue): S66-S72.

Mukhopadhyay, S., Pal, S., Mukherjee, A.K. and Ghosh, A.R. 2010. Ambient air quality in opencast coal mining area of Bankola Area (under eastern coalfield Ltd.) of Asansol–Raniganj regions. *Ecoscan*. 4(1): 19-24.

Murthy, S., Chakraborti, B. and Roy, M.D. 2010. Palynodating of subsurface sediments, Raniganj Coalfield, Damodar Basin, West Bengal. *Journal of Earth System Science*. 119 (5): 701-710.

Neogi, B., Tiwari, A.K., Singh, A.K. and Pathak, D.D. 2018. Evaluation of metal contamination and risk assessment to human health in a coal mine region of India: A case study of the North Karanpura coalfield. *Human and Ecological Risk Assessment: An International Journal.* 24 (8): 2011-2023.

Nordstrom, D.K. 2011. Hydrogeochemical processes governing the origin, transport and fate of major and trace elements from mine wastes and mineralized rock to surface waters. *Applied Geochemistry*. 26 (11): 1777-1791.

Otamonga, J.P. and Poté J.W. 2020. Abandoned mines and artisanal and small-scale mining in Democratic Republic of the Congo (DRC): Survey and agenda for future research. *Journal of Geochemical Exploration*. 208:106394.

Pal, S., Mukherjee, A.K., Senapati, T., Samanta, P., Mondal, S. and Ghosh, A.R. 2013. Surface water quality assessment of abandoned opencast coal pit-lakes in Raniganj coalfields area, India. *The Ecoscan*, IV (Special issue): 175-188.

Palit, D. and Chaudhury, A.R. 2020. Contributions of Pit Lakes to the Socioeconomic Status: A Case Study of the Raniganj Coal Field Area. In: *Environmental and Sustainable Development through Forestry and Other Resources*, Apple Academic Press, 167-194.

Palit, D. and Kar, D. 2019. A Contemplation On Pitlakes of Raniganj Coalfield Area: West Bengal, India. In *Sustainable Agriculture, Forest and Environmental Management,* Springer, Singapore, 517-571.

Palit, D., Mukherjee, A., Gupta, S. and Kar, D. 2014. Water Quality in the Pit Lakes of Raniganj coalfield, West Bengal, India. *Journal of Applied Sciences in Environmental Sanitation*. 9 (1) : 1-6.

Paliwal, P., Sengupta, A. and Dixit, N. 2021. Sustainable growth of Indian coal industry: policy perspectives and recommendations. *Journal of Mines, Metals and*

Fuels. 69 (2) : 35-44.

Pawar, G.V., Singh, L., Jhariya, M.K. and Sahu, K.P. 2014. Effect of anthropogenic disturbances on biomass and carbon storage potential of a dry tropical forest in India. *Journal of Applied and Natural Science*. 6 (2): 383-392.

Peplow, D. and Edmonds, R. 2002. Effects of Mine Waste Contamination on Fish and Wildlife Habitat at Multiple Levels of Biological Organization in the Methow River 2001-2002. Annual Report, DOE/BP-00004710-2.

Plumlee, G.S., Smith, K.S., Montour, M.R., Ficklin, W.H. and Mosier, E.L. 1999. Geologic controls on the composition of natural waters and mine waters draining diverse mineral-deposit types. The environmental geochemistry of mineral deposits. *Reviews in Economic Geology.* 6A & 6B (Part A& B): 373-432.

Rai, A.K., Paul, B. and Singh, G. 2010. A study on the bulk density and its effect on the growth of selected grasses in coal mine overburden dumps, Jharkhand, India. *International Journal of Environmental Sciences*. 1(4): 677-684.

Rawat, N.S., Saxena, A.K., Singh, G and Sundriyal, A.K. 1981. Physico-chemical characteristics of underground mine waters and x-ray analysis of corrosion products. *J. Mines, Met. Fuels; (India).* 29 (5): 108-114.

Rehman, S., Sahana, M., Dutta, S., Sajjad, H., Song, X., Imdad, K. and Dou, J. 2020. Assessing subsidence susceptibility to coal mining using frequency ratio, statistical index and Mamdani fuzzy models: evidence from Raniganj coalfield, India. *Environmental Earth Sciences*. 79 (16) : 1-18.

Sadhu, K., Adhikari, K. and Gangopadhyay, A. 2012. Effect of mine spoil on native soil of Lower Gondwana coal fields: Raniganj coal mines areas, India. *Int J Environ Sci*. 2 (3) : 1675-1687.

Saikat, M., Debnath, P. and Pinaki, C. 2020, Vegetation analysis in Chora and Joyalbhanga forest area of Raniganj coal field, West Bengal, India. *Indian Journal of Ecology*. 47(3) : 831-841.

Samanta, B.K. 2001. Ecological Engineering for Mine Water Resources in Coalfields. *National Seminar. VSE*. 2001.

Samanta, P. 2015. Impact Assessment and changes analysis of land use/land cover due to open cast coal mining activity: A case study of Raniganj coal field area. *International Journal of IT, Engineering and Applied sciences Research*. 4(5): 17-27.

Sarma, K. 2002. *Coal mining and its impact on environment of Nokrek Biosphere Reserve, Meghalaya*. Ph.D. Thesis, North-Eastern Hill University, Shillong. India.

Sarma, K. 2005. Impact of coal mining on vegetation: A case study in Jaintia Hills District of Meghalaya, India. Dissertation, International Institute for Geo-Information Science and Earth Observation Enschede, The Netherlands.

Schins, R.P. and Borm, P.J. 1999. Mechanisms and mediators in coal dust induced toxicity: a review. *Annals of Occupational Hygiene*. 43(1):7-33.

Sengupta, S. 2001. Impact of Mining on Environment in Raniganj Coalfield, West Bengal. Environment, Population, and Development: Felicitation Volume in Honour of Prof. S.L. Kayastha. 331: 1-343.

Singh, A.K., Mahato, M.K., Neogi, B and Singh, K.K. 2010. Quality assessment of mine water in the Raniganj coalfield area, India. *Mine Water and the Environment*. 29(4): 248-262.

Singh, A.K., Mahato, M.K., Neogi, B., Mondal, G.C. and Singh, T.B. 2011. Hydro geochemistry, elemental flux, and quality assessment of mine water in the Pootkee-Balihari mining area, Jharia coalfield, India. *Mine Water and the Environment*. 30 (3): 197, https://doi.org/10.1007/s10230-011-0143-7.

Singh, A.K., Mondal, G.C., Tewary, B.K. and Sinha, A. 2009. Major ion chemistry, solute acquisition processes and quality assessment of mine water in Damodar Valley Coalfields, India. Abstracts of the *International Mine Water Conference 19th – 23rd October 2009, Document Transformation Technologies, Pretoria*, 267-276.

Singh, G. 1988. Impact of coal mining on mine water quality. *International Journal of Mine Water*. 7 : 49–59, https://doi.org/10.1007/BF02504598.

Singh, G. 2008. Mitigating environmental and social impacts of coal mining in India. *Mining Engineers Journal.* June: 8-24.

Singh, R.P. and Yadav, R.N., 1995. Prediction of subsidence due to coal mining in Raniganj coalfield, West Bengal, India. *Engineering Geology*. 39(1-2): 103-111.

Sinha, M., Chaudhury, A.R. and Dutta, A. 2017. Pit Lakes and Socio-Economic Status: An Explorative Study in Raniganj Coal Field Area of West Bengal, India. *IIS Univ. J. Com. Mgt*. 6(1) : 144-169.

Slusarczyk, A. 2003. Limnological study of a lake formed in limestone quarry (Kraków, Poland). I. Zooplankton Community. *Polish J. Environmental Studies.* 12(4): 489-493.

Srivastava, S., Pal, S.K. and Kumar, R. 2020. A time-lapse study using self-potential and electrical resistivity tomography methods for mapping of old mine working across railway-tracks in a part of Raniganj coalfield, India. *Environmental Earth Sciences*. 79(13): 1-19.

Suttner, L.J. and Dutta, P.K. 1986. Alluvial sandstone composition and paleoclimate; I, Framework mineralogy. *Journal of Sedimentary Research*. 56(3): 329-345.

Tiwary, R.K. and Dhar, B.B. 1994. Environmental pollution from coal mining activity in Damodar River Basin, India. *Mine Water Environ*. 13(1): 1-10.

Tongia, R., Sehgal, A. and Kamboj, P. 2020. Future of Coal in India: Smooth Transition or Bumpy Road Ahead?. Notion Press.

Vishwakarma, A.K., Behera, T., Rai, R., Sonkar, A.K., Singh, A.P. and Shrivastva, B.K. 2020. Impact assessment of coal mining induced subsidence on native soil of South Eastern Coal Fields: India. *Geomechanics and Geophysics for Geo-Energy and Geo-Resources*. 6(1): 1-21.

Yaseen, S., Pal, A., Singh, S. and Dar, I.Y. 2012. A Study of physico-chemical characteristics of overburden dump materials from selected Coal mining areas of Raniganj Coal Fields, Jharkhand, India. *Global Journal of Science Frontier Research Enviornment & Earth Sciences*. 2: 6-13.

Yaseen, S., Pal, A., Singh, S. and Skinder, B.M. 2015. Soil quality of agricultural fields in the vicinity of selected mining areas of Raniganj Coalfield India. *Journal of Environmental & Analytical Toxicology*. 5(3): 1-6.

Younger, P.L. and Wolkersdorfer, C. 2004. Mining impacts on the fresh water environment: technical and managerial guidelines for catchment scale management. *Mine Water and the Environment*. 23: S2-S80.