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Ground Water Contamination in Coal Mining Areas: A Critical Review

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***Abstract*— Ground water is becoming a major concern with respect to surface and underground mining of coal in many state of our country coal fields. Ground-water quality is being addressed in this review paper. Despite the new emphasis placed on ground water by regulatory authorities, the effects of coal mining on ground water are still poorly understood. It is the intention to elaborate on general aspects of ground water, and to share with some results of research done in our country.**

***Index Terms*—Ground water (GW), Mining and allied activities, Contaminants, Permissible limit and Legal boundaries.**

I. INTRODUCTION

India is highly dependent on coal for meeting its commercial energy requirements. India ranks the third largest coal producer of the world next only to China and USA. Coal mining in India was started in the year 1774 in the state of West Bengal. At the beginning of 20th century, the total production of coal was just about 6 million tonnes per year. The production was 154.30 million tonnes in 1985-86 and it reached 298 million tonnes in the year 1997-98. The expectation to reach the production of coal by 2000 A.D. was 417 million tonnes (Coal India, 1997).

About 70% of India's annual coal production is used in about 72 power generating plants and produce more than 90 million tons of coal ash per year. It is likely that it may cross over 100 million tons during 2001–2010 AD (Muraka et al., 1987). The impact of coal ash leachates on receiving waters, apart from increased elemental concentrations cause changes in water pH with implications for trace element mobility (Carlson and Adriano, 1993).

Water is an essential commodity to living things and non living things and it is important in all aspect of human life. Water is used for domestic, industrial and other purposes (Mohammed 2004 and Ladan 1997). Chemically, the combination of oxygen and hydrogen forms water. As water penetrates through the ground surface to the subsurface as groundwater, impurities get into it. The public most especially the rural dwellers consume well water without due consideration of its chemical and biological composition. Perhaps this may be due to severe water problems in parts of the rural area. The quantities of water are just as important as its quality (Todd, 1959). The exploitation of the mineral resources results in the environmental degradation with large scale consequences. Although mining activities directly affects a relatively limited area of terrestrial land, its impacts on the environment, as well as on public health, may be found at greater distances from the source and for a long period (Ahanger et. al,. 2014; Boni et. al,. 1999; Balistrieri., et. al,. 1999).

Mining from exploration to the closing stage has a serious impact on the environment. This impact can be direct through the value chain activities, prospecting exploration, site development, ore extraction, mineral dressing, smelting, refining/metallurgy, transportation, post mining activities and indirectly through the impact of the degradation on the socio-cultural development of communities. In general, degradation arising from mining includes; air pollution, water pollution, land and forest degradation, noise pollution, solid and liquid waste disposal of toxic substances, as well as socio-cultural problems such as health complication, conflicts, alcoholism, communal clash and inequality.

II. GROUND WATER IN COAL MINING AREA

Rapidly deleting of groundwater supplies as a consequence of continued population growth and industrialization threaten the quality of many aquifers in India. For evaluating the suitability of groundwater for different purpose, understanding the chemical composition of groundwater is necessary. Further, it is possible to understand the change in quality due to rock-water interaction (weathering) or any type of anthropogenic inflence (Todd 1980, Kelly 1940). The defiition of water quality is much depending on the desired use of water. Therefore different uses require different criteria of water quality as well as standard method for reporting and comparing result of water analysis (Babiker 2007). Access to safe drinking water remains an urgent necessity, as 30 % of urban and 90 % of the rural Indian population still depends completely on untreated surface or groundwater resources (Kumar *et al*. 2005). Scarcity of clean and potable drinking water has emerged in recent years as one of the most serious developmental issues in many parts of West Bengal, Jharkhand, Orissa, Western Uttar Pradesh, Andhra Pradesh, Rajasthan and Punjab (Tiwari & Singh 2014). The rate of depletion of groundwater level and deterioration of groundwater quality is of immediate concern in major cities and towns of country (Meenkumari and Hosmani 2003, Dhindsa *et al*. 2004, Ramakrishnaiah *et al*. 2009: Jain *et al*. 2010; Singh *et al*. 2011; Singh *et al*. 2012; Singh *et al*. 2013; Tiwari and Singh 2014, Singh *et al*. 2014, Tiwari *et al*. 2014).

III. IMPACT OF COAL MINING ON GROUND WATER

The problems caused by mining activities are land degradation, disposal of over burden, deforestation, washing rejects, subsidence, water pollution due to wash off, discharge of mine water, acid mine drainage, coal washing operation, air pollution due to release of gases and dust, noise pollution,

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mine fires, damage to forest flora and fauna, wildlife habitat destruction and occupational health hazards (Singh et. al.2011 Ahanger et. al,. 2011)

Mining is a major anthropogenic activity causing water pollution and environmental degradation (Allen, et. Al.,1996; Choubey,1991;Galero, et. al.,1998; Ratha and Venkataraman, 1997).

Groundwater, which is the most important sources of water in semi-arid region of Bundelkhand is currently overexploitation and threatened by mining activities. Groundwater in hard-rock aquifers, particularly in mining areas, is known to be vulnerable to quality problems that may have serious impact on human health. In general, mining has impacts on all elements of the environment, its point and diffuse source pollution presents catchment-scale and transponder impacts. Mine disposals including dumps and tailings piles are a ubiquitous feature of both surface and underground mining. Open cast mining operations and the resultant huge overburden dumps leads to numerous devastating environmental effects, of them water pollution is considered an important one. Water pollution in mining areas can occur in two basic ways – physically and chemically. Physical impact mainly results from silting in the surface water bodies. Deterioration in drinking water quality is a serious human health issue. Mining activities are known to release both major and trace elements into the environment. Trace elements or the heavy metals are classified among the most dangerous groups of pollutants due to their toxicity and persistence in the environment (Nyarko, et. al., 2008 and Carreras, et. al., 2009). Metals in the contaminated soils and water may reach human body through agricultural products (Rulkens, et. al.,1998; Sponza and Koraoglu, 2002; Haroon, et. al., 2010). Leaching of heavy metals from the mine spoils is possible during the rainy season thereby contaminating the groundwater.

IV. SOURCE OF GROUND WATER CONTAMINATION

Mohanty et al. (2001) studied the sequential leaching of trace elements in coal from Talcher coalfields from Seam I of Deulbeda colliery and Seam II of Jagannath colliery and concluded that the trace elements are mostly bonded to soluble oxides and sulphide minerals present in the coal. Fang et al. (2003), have shown how the trace element from coal mining activities contaminates the ecosystem of Badao Bone coal mine in China. Bonacci (1995) has shown the behaviour of karsts in groundwater system. Ebraheem et al. (1990) studied the acid mine drainage, which is formed during the process of mining, by using earth resistivity measurements. Charles (1998) and Jaynes et al. (1984) have described the effect of sewage sludge on groundwater. at a reclaimed coal mine. Rushton and Redshaw (1979) have shown how the seepage will occur in the aquifer system and contaminant migrates with groundwater flow system. The main source of potable water in the area is groundwater, which is tapped by shallow dugwells, and deep borewells. Groundwater is valuable only when its quality is suitable for which it is being explored. Suitability of groundwater/surface water for a particular purpose depends upon the acceptable water quality standards for which it is being used (WHO, 1984; USPHA, 1993).

In coal mining and industrial areas, the surface and ground water is usually polluted and contaminated. In such areas, water is being contaminated by overburden dump. Surface impoundments, artificial recharge, waste disposal in wet excavation, mine water, industrial effluents, acid mine drainage, tailing pods, etc. (Chandra, 1992). The water bodies of this area are the greatest victims of such operations (Abishek, et.al., 2006). Several environmentalist have studied environmental impact of coalmining across the globe (Chadwick et.al., 1987; Filho,1994; Tiwary and Dhar, 1994; Tiwary, 2001; Swer and Singh, 2004). The effluents of coke oven plants and coal beneficiation plants result water pollution. The coal washeries discharges effluents containing coal fines from the sedimentation tanks pours into river or stream causes environmental pollution (Tiwary and Abhishek, 2004 & 2005).

V. HEAVY METAL POLLUTION

Coal mining activity in India started decades back, since then the groundwater is getting affected with coal mining, leachates generated from large number of industrial waste and overburden dumps that are in abundance around the mining areas, may reach the groundwater and may adversely affect its quality (Khan *et al.* 2005; Mohammad *et al.* 2010). Groundwater contamination is one of the most important environmental problems in the present world where metal contamination has major concern due to its high toxicity even at low concentration (Marcovecchio *et al.* 2007; Momodu and Anyakora 2010). Heavy metals contamination in the groundwater is one of the major issues in many fast growing cities (Sundaray *et al.*, 2006; Akoto *et al.*, 2008; Ahmad *et al.*, 2010*)*. Enhancement of heavy metals contamination of the groundwater is one of the serious environmental issues. Some of the heavy metals considered as micronutrients become detrimental to human health when their concentrations exceed the permissible level of drinking water (Prasanna *et al.* 2011). Rapid urbanization, especially in developing countries like India has affected the availability and the quality of the groundwater due to its overexploitation and improper waste disposal, especially in urban areas (Ramakrishnaiah et.al. 2009). The weathering of natural resources such as rocks bearing minerals is one of the major causes of heavy metal contamination in groundwater; anthropogenic sources include fertilizers, industrial effluent and leakage from service pipes. Heavy metals occur in the earth's crust and may get solubilised in ground water through natural processes. Moreover, groundwater can get contaminated with heavy metals from landfill leachates, seawage leachates from mine tailings, deep well disposals of liquid wastes, seepage from industrial waste lagoons or from industrial spills and leaks. Usually in unaffected environments, the concentration of most of the metals is very low and is mostly derived from the mineralogy and the weathering (Karbassi *et al.*, 2008). Main anthropogenic sources of heavy metal contamination are mining, disposal of untreated and partially treated effluents contain toxic metals, as well as metal chelates from different industries and indiscriminate use of heavy metal-containing fertilizer and pesticides in agricultural fields (Hatje *et al*., 1998; Amman *et al*., 2002; Nouri *et al.,* 2006; Nouri *et al.,* 2008). However, public ignorance of environment and related considerations, lack of provisional basic social services, indiscriminate disposal of increasing anthropogenic wastes, unplanned application of agrochemicals, and discharges of improperly treated sewage/industrial effluents; result in excess accumulation of pollutants on the land surface and contamination of water resources (Tiwari *et al*. 2013; Singh *et al*. 2014). The studies carried out by various researchers on water quality by using different water quality indices across India, including Jharkhand (Giri *et al*. 2010; Giri *et al*. 2012; Singh *et al* 2013a, Prasad *et al*. 2014, Tiwari *et al*. 2014, Singh *et al*. 2014). Scarcity of clean and potable drinking water has emerged in recent years as one of the most serious developmental issues in many parts of West Bengal, Jharkhand, Orissa, Western Uttar Pradesh, Andhra Pradesh, Rajasthan and Punjab (Tiwari & Singh 2014).

VI. LEGAL ASPECTS OF GROUND WATER POLLUTION

Surface mine operators and companies are concerned about ground water with respect to their legal obligations for protection of groundwater quality and quantity. First, there are requirements for certain data and plans in the surface mining permit application. Second, there will be monitoring requirements during surface mining, and third, there are water quality standards which must not be violated. Only water quality standards will be reviewed in detail.

Concerning information needed for the mining permit, the following quality information is required or will soon probably be required of surface: (1) pre-mining surveys of ground water, including sampling of all water supply wells and springs within 10km. of the mine site, and chemical analyses of these waters for at least pH, total suspended solids, iron, and manganese; (2) characterization of water quality for each aquifer between land surface and the lowest mined coal (including the aquifer just beneath this coal), for pH, suspended solids, iron, and manganese. If wells or springs are not available for sampling and analysis to represent some aquifers, then new wells must be drilled; (3) description of how the potential for ground-water pollution will be minimized, and what pollution is likely to occur; (4) a plan for treatment of pond, pit, or stream waters before they infiltrate, to correct future ground-water pollution should it occur; (5) identification of alternate water-supply sources for ground-water users whose present supplies may become polluted; and (6) a plan for ground-water quality monitoring, involving wells, to be implemented where future pollution is judged probable for areas within 10km. of the mine site. It is likely that easily-pollutable ground water at springs and wells will have to be monitored at least once every three months, for at least pH, total suspended solids, iron, and manganese. Probably at least one new well will have to be drilled downhill from the mine site, if no other nearby wells are present.

VII. PREVENTIVE AND CORRECTIVE MEASURES

Several actions can be taken to lessen the chances of ground-water pollution occurring because of surface mining. Ground water should be directed away from the mine site both during and after mining, where possible. This objective should be easier to achieve for contour mines than for area mines. In contour mines, drainage pipes can be installed in ditches dug at the foot of the high walls just prior to reclamation. This will result in lower water tables after reclamation, and less ground-water contact with fill material. Ground-water drainage could then be directed in pipes towards a nearby stream channel. Another approach would be to install an impermeable barrier in the backfill material, a few feet below the surface. This would have the effect of directing infiltrating rainfall downslope away from the mine and buried toxic overburden. Where possible, surface mining should be kept at least 2km away from any well or spring water supply, especially those supplies located downhill from the mine. Also, all bore holes created by coring operations and all old abandoned wells should be filled with concrete grout at the mine site during mining. Otherwise, polluted mine drainage may recharge aquifers underlying the mine. Likewise, wells drilled near the mine to monitor ground water should be grouted following mine reclamation.

Certain corrective measures can be taken after ground-water pollution is detected. One should first locate and stop discharges from specific pollution sources on the surface mine site, if possible, before reclamation is completed. This could include channeling mine surface water into treatment ponds that are lined with impermeable bottoms. Second, new water supplies should be located for persons whose wells or springs have become polluted. The most dependable water supply would be piped water from a water service district. If piped water is too far away to be economically feasible, then the choices would be a new well, a cistern or a nearby spring. Of these, a new well is definitely preferable. It should be located as far away from the mine as possible and away from other potential pollution sources such as septic tanks, acid streams and other mines; it should also be properly constructed and sealed, and have enough casing to seal off the upper shallow ground-water zone. If possible, a deeper aquifer with potable ground water should be tapped for a water supply. New well drilling and construction should be handled by an experienced water-well driller.

VIII. GROUND WATER QUALITY

The overall quality of the water is regulated by the Indian standard IS 10500 (2012) by BIS.

pH: pH is important parameter, which determines the suitability of water for various purposes having desirable limit i.e., 6.5 to 8.5 as specified by IS 10,500.

- Calcium: The desirable limit and permissible limit of calcium for drinking water as specified by IS: 10,500 is to be within 75 mg/l to 200 mg/l.
- Magnesium: The desirable limit and permissible limit of magnesium for drinking water as specified by IS: 10,500 is, 30mg/l to 100 mg/l.
- Sulphate: The desirable limit is 200-400mg/l.
- TDS (Total Dissolved Solid): Total dissolved solids permissible limit 500-2000mg/l.
- Alkalinity: The standard desirable limit of alkalinity of potable water is 120 mg/l and the maximum Permissible level is 600 mg/l for drinking water as specified by IS: 10,500.

- Hardness: The desirable limit and permissible limit of total hardness value for drinking water as specified by IS: 10,500 is to be within 300 mg/l to 600 mg/l.
- Nitrate: According to Is 10,500 the desirable and permissible limit for nitrate in drinking water is 45 mg/l and 100 mg/l.
- Fe (Iron): The desirable and permissible limit of Fe for drinking water as specified by IS: 10,500 is to be within 0.3 mg/l to 1 mg/l.
- Turbidity: The desirable limit and permissible limit of Turbidity for drinking water as specified by IS: 10,500 is to be within 5 NTU to 10 NTU.
- Fluoride: The desirable limit and permissible limit of Fluoride for drinking water as specified by IS: 10,500 is to be within 1 mg/l to 1.5 mg/l.
- Chloride: The desirable limit and permissible limit of Fluoride for drinking water as specified by IS: 10,500 is to be within 1 mg/l to 1.5 mg/l.

IX. Conclusion

The composition of ground water varies widely with local geological conditions. Neither groundwater nor surface water has ever been chemically pure, since water contains small amounts of gases, minerals and organic matter of natural origin. Mining is widely regarded as having adverse effects on environment of both magnitude and diversity. Some of these effects include erosion, formation of sinkhole, biodiversity loss and contamination of groundwater by chemical from the mining process in general and open pit mining in particular.

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References

[1] Abhishek, R.K.Tiwary and S.K.Sinha, 2006, "Status of Surface and Groundwater Quality in Coalmining and Industrial Areas of Jharia Coalfield", *International Journal of Environmental Protection* (IJEP), Vol.26 (10):pp.905-910.

[2] Ahanger Faroz Ahmad, Sharma Harendra K., Rather Makhmoor Ahmad And Rao R. J, (2014) Impact Of Mining Activities On Various Environmental Attributes With Specific Reference To Health Impacts In Shatabdipuram, Gwalior, India. *International Research Journal Of Environment Sciences* Vol. 3(6), pp 81-87.

[3] Ahmad MK, Islam S, Rahman S, Haque MR, Islam MM. ,2010, Heavy metals in water, sediment and some fishes of Buriganga River, Bangladesh. International Journal of Environmental Research 4(2), 321-332.

[4] Akoto O, Bruce TN, Darko G. ,2008, Heavy metals pollution profiles in streams serving the Owabi reservoir. African Journal of Environmental Science and Technology 2(11), 354-359.

[5] Allen, S.K., Allen, J.M., Lucas, S. ,1996, "Concentration of contaminants in surface water samples collected in west-central Indiana impacted by acid mine drainage," Environ. Geol. XXVII, pp. 34–37. Choubey, V.D ,1991, "Hydrological and environmental impact of coal mining, Jharia coalfield, India," Environ.Geol. XVII, pp.185–194.

[6] Ammann AA, Michalke B, Schramel P. 2002. Speciation of heavy metals in environmental water by ion chromatography coupled to ICP-MS. Analytical and bioanalytical chemistry 372(3), 448-452.

[7] Babagana Gutti, Mohammed M. Aji And Garba Magaji, 2012 Environmental Impact Of Natural Resources Exploitation In Nigeria And The Way Forward *Journal Of Applied Technology In Environmental Sanitation.* Vol. 2, No. 2 Pp 95-102.

[8] Babiker I. S., Mohamed M. A. A., Hiyama T., Assessing groundwater quality using GIS, *Water Resour Manage,* 21 : 699-715.(2007).

[9] Balistrieri L.S., Box S.E., Bookstrom A.A. And Ikramuddin M., 1999, Assessing The Influence Of Recreating Pyrite And Carbonate Minerals On The Geochemistry Of Drainage In The Coeur D'alene Mining District, *Environmental Science & Technology*, 33, 3347-3353

[10] BIS., Indian standard drinking water specifications IS10500:2012, *Bureau of Indian Standards*, New Delhi, (2003).

[11] BONACCI, O. ,1995, Groundwater behaviour in Karst: Example of the Ombla Spring (Croatia). *Jour. Hydrology*, v.165, pp.113-134.

[12] Boni M., Costabile S., De, Vivo B. And Gasparrini M.,1999, Potential Environmental Hazard In The Mining District Of Southern Iglesiente (Sw Sardinia, Italy), *Journal Of Geochemical Exploration*, 67, 417-430

[13] Carlson, C.L., and D.C. Adriano. 1993. Environmental impacts of coal combustion residues. J. Environ. Qual. 22:227–247.

[14] Carreras, H.A., Wannaz, E.D and Pignata, M.L. , 2009,. "Assessment of human health risk related to metals by the use of biomonitors in the province of Cordoba, Argentina," Environ. Pollut. pp.157-117.

[15] Chadwick, M.J., N.H. Highton and N.Lindman, 1987, *Environmental impacts of coal mining and utilization,* Pergamon Press, Oxford.pp 5-211.

[16] Charles Cravatta III ,1998, Effect of sewage sludge on formation of acidic groundwater at a reclaimed coal mine. *Ground Water*,v.35(6), pp.9-19.

[17] Dhindsa S. S., Bheel P. and Musturia y. ,2004, Hydrochemical study of ground water quality variation in Tonk District, Rajasthan, *Indian Journal of Environment and Ecoplanning*, 8(1): 129–136,.

[18] Dzombak DA, Morel FMM. ,1997, Adsorption of Inorganic Pollutants in Aquatic Systems. Journal of Hydraulic Engineering 113, 430-475.

[19] Ebraheem, A.M., Hamburger, M.W., Bayless, E.R. And Krothe, N.C. ,1990, A study of acid mine drainage using earth resistivity measurements. *Ground Water*, v.28(3), pp.361-368.

[20] FANG, W.X., HUANG, Z.Y. and WU, P.W. ,2003, Contamination of the environmental ecosystems by trace element from mining activities of Badao Bone Col mine in *China. Environ. Geol*., v.44, pp.373-378.

[21] Filho, Evaristo Ribeiro. ,1994, The impact of mining on the environmental: Necessary evil or merely a calamity ? *In the impact of mining on the environment : Problems and solutions*. A.A. Balkema, Rotterdam.

[22] Flocculation of trace metals during mixing of Talar river water with Caspian Seawater. International Journal of Environmental Research 1(1), 66-73.

[23] Galero, D.M., Pesci, H.E., Depetris, P.J. ,1998, "Effects of quarry mining and of other environmental impacts in the mountainous Chicam-Toctina drainage basin (Cordoba, Argentina)," Environ. Geol. XXXIV, pp.159–166. Ratha, D.S., Venkataraman, G. ,1997, "Application of statistical methods to study seasonal variation in the mine contaminants in soil and groundwater of Goa," India. Environ. Geol. XXIX, 253–262.

[24] Giri S, Mahato MK, Singh G, Jha VN. ,2012, Risk assessment due to intake of heavy metals through the ingestion of groundwater around two proposed uranium mining areas in Jharkhand, India. Environmental monitoring and assessment 184(3), 1351-1358. Giri S, Singh G, Gupta SK, Jha VN, Tripathi

RM. ,2010, An Evaluation of Metal Contamination in Surface and Groundwater around a Proposed Uranium Mining Site, Jharkhand, India. Mine Water and the Environment 29(3), 225-234.

[25] Haroon, G., Khoiyangbam, R.S., Ahmad, S. and Zuber, S.M., 2010,. "Trace Metal Levels in the Muscle Tissues of Ctenopharyngodon Idella (Grass Carp) and Ophiocephalus (Snake Headed Fish) of Antiya Tal of Jhansi City (U.P.)," International Journal of Applied Environmental Sciences. V (4), 505–512

[26] Hatje V, Bidone ED, Maddock JL. 1998. Estimation of the natural and anthropogenic components of heavy metal fluxes in fresh water Sinos river, Rio Grande do Sul state, South Brazil. Environmental Technology 19(5), 483-487. Karbassi AR, Nouri J, Ayaz GO. 2007.

[27] Jain C. K et al., ,2010, Assessment of ground water quality for drinking purpose, District Nainital, Uttarakhand, India, *Environmental monitoring and assessment*, 166(1-4): 663-676,. Kelley., WP ,1946, Permissible composition and concentration of irrigation waters In: Proceeding *American Society of Civil Engineering*,.

[28] Jaynes, D.B., Rogowski, A.S. And Pionke, H.B. ,1984, Acid mine drainage from reclaimed coal strip mines, 1. Model Description, *Water Resources Res.,* v.20(2), pp.233-242.

[29]
Khan S, Cao Q, Zheng YM, Huang YZ, Zhu YG. 2005. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environmental Pollution 152, 686–692.

[30] Kumar, R. et al. 2005, Water resources of India, *Curr Sci.,* 89: 94–81. Meenakumari H. R. and Hosmani, S. P.,Physicochemical ,2003, biological quality of ground water in Mysore City, Karnataka, *Indian Journal of Environment and Ecoplanning*, 7(1): 79–82.

[31] Marcovecchio JE, Botte SE, Freije RH. 2007. Heavy Metals, Major Metals, Trace Elements. In: Handbook of Water Analysis. L.M. Nollet, (Ed.). 2nd Edn. London: CRC Press, pp: 275-311.

[32] Mohammad Mehdi Heydari, Ali Abasi, Seyed Mohammad Rohani, Seyed Mohammad Ali Hosseini. 2010. Correlation Study and Regression Analysis of Drinking Water Quality in Kashan City, Iran. Middle-East Journal of Scientific Research 13(9), 1238- 1244.

[33] Mohanty, J.K., Mishra, S.K. And Nayak, B.B. ,2001, Sequential leaching of trace elements in coal: A case study from Talcher coalfield, Orissa, *Jour. Geol. Soc. India*, v.58(5), pp.441-447.

[34] Momodu MA, Anyakora CA. 2010 Heavy Metal Contamination of Ground Water: The Surulere Case Study. Research Journal Environmental and Earth Sciences 2(1), 39 -43.

[35] Muraka I. P. et al., 1987, Solid waste disposal and reuse in the United States (ed.), I P Muraka (Boca Raton F L: CRC Press Inc.), 95.

[36] Nouri J, Mahvi AH, Babaei A, Ahmadpour E. 2006. Regional pattern distribution of groundwater fluoride in the Shush aquifer of Khuzestan County Iran Fluoride. Fluoride. 39(4), 321-325.

[37] Nouri J, Mahvi AH, Jahed GR, Babaei AA. 2008. Regional distribution pattern of groundwater heavy metals resulting from agricultural activities. Environmental Geology 55(6), 1337-1343 . Prasad B, Kumari P, Bano S, Kumari S. 2014. Ground water quality evaluation near mining areaand development of heavy metal pollution index. Applied Water Science 4, 11–17. Prasanna MV, Praveena SM, Chidambaram S, Nagarajan R, Elayaraja A. 2011. Evaluation of water quality pollution indices for heavy metal contamination monitoring: a case study from Curtin Lake, Miri City, East Malaysia. Environmental Earth Science. doi:10.1007/ s12665-012-1639-6.

[38] Nyarko, B.J.B., Dampare, S.B., Serfor-Armah, Y., Osae, S., Adotey, D., Adomako, D. , 2008, "Biomonitoring in the forest zone of Ghana: the primary results obtained using neutron activation analysis and lichens," Int. J. Environ. Pollut. XXXII, pp.467.

[39] Ramakrishnaiah, C. R. et al. ,2009, Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State, India, *Journal of Chemistry,* 6(2): 523-530.

[40] Rulkens, W. H., R. Tichy and J.J.C, Grotenchuis , 1998, Remediation of polluted soil and sediment: Perspectives and failures, Journal of Water Sci.Technol. XXXVII, pp.27-35.

[41] Rushton, K.R. And Redshaw, S.C. (1979) Seepage and Groundwater Flow, *John Wiley Publication,* 1-339.

[42] 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 Pootkeebalihari Mining Area, Jharia Coalfield, India, *Mine Water And The Environment*, 30(3), 197-207

[43] Singh P, Tiwari AK, Singh PK. 2014. Assessment of Groundwater Quality of Ranchi Township Area, Jharkhand, India by Using Water Quality Index Method. International Journal of ChemTech Research 7(01), 73-79.

[44] Singh P, Tiwari AK, Singh PK. 2014. Hydrochemical characteristic and Quality Assessment of Groundwater of Ranchi Township Area, Jharkhand, India. Current World Environment 9(3), 804-813.
Singh PK, Tiwari AK, Mahato MK. 2013a. Qualitative Assessment of Surface Water of West Bokaro Coalfield, Jharkhand by Using Water Quality Index Method. International Journal of ChemTech Research 5(5), 2351-2356.

[45] Singh P., Tiwari A. K. and Singh P. K. ,2014, Hydrochemical characteristic and Quality Assessment of Groundwater of Ranchi Township Area, Jharkhand, India, *Current World Environment,* 9(3): 804-813, doi: http://dx.doi.org/10.12944/CWE.9.3.30.

[46] Singh, A. K. et al. ,2012, Hydro geochemical processes and quality assessment of groundwater in Dumka and Jamtara districts, Jharkhand, India, *Environmental Earth Sciences*, 67(8): 2175-2191.

[47] Singh,A. K. et al. ,2011, Major ion chemistry, weathering processes and water quality assessment in upper catchment of Damodar River basin, India, *Environ. Geol.,* 54: 745–758.
Tiwari A. K. and Singh A. K., 2014, Hydrogeochemical investigation and groundwater quality assessment of Pratapgarh district, Uttar Pradesh, *Journal of the Geological Society of India,* 83(3): 329-343,.

[48] Sponza, D., Koraoglu, N., 2002, Environmental geochemistry and pollution studies of Aliaga metal industry district. Journal of Environmental International, 27, 541-552.

[49] Sundaray SK. 2009. Application of multivariate statistical techniques in hydro-geochemical studies-a case study: BrahmaniKoel River (India). Environmental monitoring and assessment 164 (1-4), 297-310.

[50] Swer, Sumarlin and O.P.Singh, 2004, "Status of water quality in coal mining areas of Meghalaya, India", *National Seminar on Environmental Engineering with special emphasis on mining environment*, Proceedings, pp 173-181.

[51] Tiwari A. K., Singh P. K. and Mahato M. K., 2014, GIS-Based Evaluation of Water Quality Index of Groundwater Resources in west Bokaro Coalfild, India, *Current World Environment,* 9(3): 843-850,.

[52] Tiwari AK, Singh AK. 2014. Hydrogeochemical investigation and groundwater quality assessment of Pratapgarh district, Uttar Pradesh. Journal of the Geological Society of India 83(3), 329-343.

[53] Tiwari AK, Singh PK, Mahato MK. 2013. Chemistry of Groundwater and Their Adverse Effects on Human Health: A Review. Indian Journal of Health and Wellbeing 4(4), 923-92.

[54] Tiwary, R.K and Abhishek, 2004, " Impact of coal mining and allied industries on the aquatic environment in Jharia coalfield. National

Seminar on Pollution in urban industrial environment, Bhubaneswar, Proceedings, pp 41-49.
[55] Tiwary, R.K and Abhishek, 2005, "Impact of coal washeries on water pollution of river Damodar in Jharia coalfield, *Indian J. Env.Prot.*, 25(6): 518-522.
[56] Tiwary, R.K and B.B.Dhar 1994, " Effect of coal mining and coal based industrial activities on water quality of the river Damodar with special reference to heavy metals. *Int. Jr Surface Mining, Reclamation Env.*, 8:111-115.
[57] Tiwary, R.K.200, "Environmental impact of coal mining on water regime and its management. *Water Air Soil Poll*., 132:185-199.
[58] Todd O. K ,1959, Ground Water Hydrology. Reprint Edition, John Wiley And Sons Inc. New York. Chandra, C.1992 Jharia Coalfield, *Geological Society Of India*, Bangalore. Pp 1-11.
[59] Todd, D., Ground water hydrology (2nd edn). Wiley, 1980, New york. pp 535,.
[60] USPHA ,1993, International standards for drinking water, United States Public Health Association, *US Govt. Printing Office*, Washington DC, pp.75-88.
[61] WHO ,1984, Guidelines for drinking water quality, *World Health Organisation*, Washington DC, pp.333-335.
[62] WHO.,1997, Guidelines for drinking-water quality. vol 1, Recommendations. *World Health Organisation*, Geneva, pp 1–4.

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