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RESEARCH ARTICLE

WASTE WATER IN MINES AND STATUS OF UTILIZATION.

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Abstract

The quality of water in mines at production stage affects the working of mines and surrounding water regime significantly. In many mineral producing countries, the pre-mining prediction of water quality is must for getting lease or license for mining operations. In this paper, various methodologies for prediction of the water quality in terms of pH, TDS, conductivity and metal concentration at the exploration stages were discussed. Such adverse information before start of mines is not only be useful for planning the water pollution control in advance but also help in mitigation of ill effects on mining on surrounding water regime.

Introduction:-

The present world population 7.3 billion expected to increases 8.5 billion in year 2030, 9.7 billion by 2050 and exceed 11 billion in year 2100. India's expected population will be 1.52 billion in year 2030, expected to surpass China's population (United Nations department of economic and social affairs report, 2015). More than 2 billion world population are expected to dwell in urban areas by 2030.As the world's population grows very fast, migrates towards towns, and improves in standard of living, for balancing the genuine demand of the population .There has been required exponential growth in the production of coal, ores and minerals for met needs of huge population of develop and developing counties. Mining sector has extra demand of water for fast growing, and uses water in remote areas where it often 'self-supplies'. Mining industries discharges huge quantities of mine water to the natural environment, which pose serious risk to water quality. The water demand increases due to higher living standards, expected global water demand will be 6000 billion m^3 in 2025 (Green Planet Monitor, 2011).In India approximately 7453 square Kilometres area covered by 9906 mining leases. For extracted minerals over 3200 operating mines (Tiwary et al.,2000).Mine water also known as Acid Mine Drainage (AMD) is caused by the weathering of pyrite, in presence of oxygenated water (water and oxygen), oxidation and hydrolysis reactions produce free hydrogen ions (H^+) and sulphuric acid (H_2SO_4). Mine water degrade the water resources (surface and sub surface) (Azapagic, 2004), affects the neighbouring mining area, lowering the water table, disturbed the natural drainage pattern. Due to different mining activities.

Acid Mine Drainage (AMD) or mine water (MW) and its contaminants associated with it is the most hazardous environmental pollution, its quality and quantity vary from mines to mines and site-to-site, worldwide, the prediction of mine water can be very challenging and costly task (Singer and Stumm, 1970). Acid Mine Drainage has low pH (2-4) (Jamal et al., 2015; Yadav et al., 2015, 2015), high acidic in nature contains hazardous toxic non-biodegradable heavy metals pollutants i.e. heavy metals particularly, aluminum, Cadmium, Copper, Iron, Lead, Zinc; etc.That is heavily dependent upon mineral products from expanded mining activities worldwide. Many researchers show the scarcity of water availability for the mining industry for different mining activities, due to change in climate, rain fall patterns, and water rules and legislation (Salmon, 2006; Dash, 2012), exploration of natural resources like coal, ore and metals are increasing for economic growth and fulfilment of demands of world population, in mining impacted catchments and the respective competition for the limited water resource or because of declining ore grade and related increase in material to be mined and processed (Norgate and Lovel, 2006) or due to global warming, results in serious scarcity of fresh water (Koch et al., 2005, 2009). When the surface mines ceases to operate, development Pit Lake is an effective and pragmatic end use for mine water (MW) (Warhurst and Noronha, 1999; Geller et al., 2013).

Requirement of water in mining industries:-

In coal mine approximately 509 litres of water are required to produce 1.0-2.0 tonnes of coal, and realise an average four tonnes of pit water are drained (Zhong, 2001). The demand of water also depends on quality of coal and technology used in coal extraction from mines. The mining industries required water for different mining activities e.g. transportation of ore and waste materials in slurries and suspension, separation of different ore and minerals through chemical processes. Physical separation of material such as in centrifugal separation, used for cooling systems around power generation, mitigation of dust during coal and mineral processing and haul roads cleaning with mining equipment and dewatering of mines. Presently, mine pits fulfil 75% water demand of coal mining project. In coming future, Coal India Limited (CIL) is likely to create about 3.3 billion $m^3$of water resources, on an average in its open cast coals mines alone and help significantly towards water security of the country (Debnath, 2013).

Characteristics of mine water:-

The quality of mine water generally depends on types of rocks. Mine water may be acidic or alkaline in nature have heavy metals, total dissolve solids 500 mg/L to 2000 mg/L, hardness ranges between 500-2000 mg/L as $CaCO_3$, suspended solids 10-100 mg/L electrical conductivity 600-10000 us/cm, $BOD_{5,}$5 mg/L and COD, 10-100mg/L found in a good deal of many literature (Dharmappa et al.,1999;Yadav et al., 2015).Mine water pumped from underground and open pits mines content iron or more precisely also manganese ions, sulphates anions, hydrogen carbonates, acid pH, all above in consequence of iron sulphides oxidation (pyrite, marcasite),which are incorporated inside of coal mater.The mine influence water have very poor quality and severally impacts on human health, plants, animals, flora, fauna, surface and ground water resources (Bengao and Cababat,2014; Chang et al., 2003;Cui et al., 2012; Hu et al., 2012; Jamal et al., 2015,Yadav et al., 2015,2015).

Pre-prediction of mine water drainage quality:-

The pre-mining prediction of drainage quality is governed by many natural factors like, geological, geochemical, geotechnical and atmospheric factors in corporation of amount of acid generating minerals occurring in coal and its associated rocks, acid neutralizing carbonate and alkali bases minerals present in overburden and, types of contamination present in rocks and coal, types of pyrites minerals present and their occurrence, types of carbonates and alkali based hydroxide minerals, available surface of waste and coal for reaction, availability of water, oxygen, and bacteria. Static and kinetic method are used for prediction, the first method are used for determine total acidic generation and neutralization capacity of the coal and associated rocks and second method simulates the process at mining sites at an accelerated rate, the results from these test are used to identify acidic producing and acidic neutralizing capacity of different litho-units in the given sedimentary formation.

Utilization of mine water as water resources:-

Globally all coal, ore and metal mines discharging huge amount of mine waste water which can be effectively utilized in different purposes (Banks et al., 1996, Wolkersdorfer, 2008), direct ally or indirect ally after small treatment. Although mining activities also required water for different mining operations and its related activities e.g. for coal washing, cooling in deep mine working, concentrate production, ore processing, dust mitigation from haul roadways, disposal of fly ash from thermal power plant, at surface and underground many developed nation effectively reused mine water in place of fresh domestic water.

Literature shows the mine water are used for filling pit lakes which increase water table, nature conservation, recreation or flood control, fisheries, aquaculture, fire fighting and agricultural uses. Mine water also maintains the water balance. Reuses of mine water for different mining activities reduced the demand of fresh water which can be utilized for other purposes (Norgate and Lovel, 2006; Wright and Vleggaar,2006), many natural process are available for conservation of water for the stabilization of the regional water balance (Arnold and Rolland, 2005; Kulik and den Drijver, 2006; Wolkersdorfer, 2008; Niekerk 2009).Abounded and pit lakes mine water are utilizes for recreation, aquaculture and for fisheries (Axler et al.,1998;Miller, 2008; Wolkersdorfer, 2008; McCullough et al.,2009; Schultze, 2010).Many Active and abounded mines influences water are utilizes as Cooling water in thermal power plants (Vel, and Puder, 2006; Watzlaf and Ackman, 2006; Wolkersdorfer, 2008; Geothermal heat (Watzlaf and Ackman, 2006; Renz et al., 2009; Whitebread-Abrutat and Coppin 2011) Hydropower (Wolkersdorfer, 2008; Loredo et al., 2011).Active mine water (Bahrami et al. 2007; Barrett et al., 2010;Bender et al., 2010; Holten and Stephenson, 1983; Loveday et al., 1984),Filling of pit lakes (Schultze et al., 2011). Active and pit lakes mine water are used for Nature conservation(Arnold and Rolland,2005; Kulik and Drijver 2006; McCullough et al., 2009; Schultze et al.,2012) Many country uses mine water for prevention of Pollution at sources on the mines, minimization of possible impacts by mitigation measures, recovery and reuses of water for different purposes on mines and mine complex and after Treatment mine waste water can be used for agricultural, fisheries, navigation and discharges in stream, river, lakes ponds (D Souza et al., 2004; Mey et al., 2006; Younger, 2006; Grunewald, 2009; Laredo et al., 2010;Yadav et al., 2015).

Active, abounded and pit lakes mine water are utilizes for different domestic and industrial purposes (Wolkersdorfer, 2008; MCCullough, 2008; McCullough et al., 2009; Karakatasanis and Cogho, 2010). Mine water used for irrigation, purposes (du Plessis,1983; Paid Harper et al., 1997; 2009; McCullough et al., 2009); it is also utilize as raw sources for recovery of different heavy metals (Wolkersdorfer, 2008; Rapantova et al.2009; Gammons and Tucci, 2012), Stabilisation of regional water balance, water storage and flood protection (Kaden et al. 1985; Norgate and Lovel, 2006;Grünewald, 2009; Loredo et al.2010; Schultze et al.,2012), In china recently new technology goafs is used for underground mine water treatment. The treated mine water is injected into the high laying area of the goaf to lead it to flow by itself because the coal gangue in the goaf has the capacity of filtration, adsorption and purification of mine water such as filtration, precipitation, adsorption and ion exchange as well as removal of Fe^{2+}, Mn^{2+} from mine water. These treated mine water is utilized for ground production water, ground domestic water, underground dust removal water and underground fire fighting water,(Chen et al.,2014), table-1 shows the potential for water conservation in Coal India Limited (CIL) project in India. It is estimated from table-1, Coal India Limited have capacity of pit lakes which can efficiently hold water for aquaculture, promote tourism, water for agricultural purpose to irrigate 3060647.5 acre area or support 43,000 MW electric power generations and for socio-economic development of the mine area.

Table: 1, Potential of Water Conservation in Coal India Limited (CIL) projects

Potential of Water Conservation in Coal India Limited (CIL) Projects						
S No.	Mine	Types of mine	Void area, Ha	Mine Void Depth, m	Relative Depth, %	Volume of water stored, million m^3
1.	Gevra	Opencast	659.25	290.00	10.01	1035.00
2.	Dipka	Opencast	570.00	128.00	4.75	425.00
3.	Kusmunda	Opencast	199.32	235.00	14.75	300.00
4.	Manikpur	Opencast	188.00	60.00	3.87	85.oo
5.	Kartali	Opencast	233.61	242.00	14.03	273.00
Total volume of water storage potential is 2118 million m^3						

(Sources CIL report)

Potential of geothermal energy in India’s abandoned mines:-

India have 3200 mines out of these 574 are coal mines having approximately 550 MT/year coal production out of these least 297 are inactive (abandoned) (IBM, 2003) coal mines where no reclamation has taken place out of these 82 abandoned mines identified by Indian Bureau of Mines (IBM, 2003), out of these 42 mines are in the state of Madhya Pradesh, Chhattisgarh and Jharkhand. Andhra Pradesh also has 8 inactive (abandoned) mines in different location which can be utilized for power production. That energy can be used for different industrial and domestic purposes for heating and cooling of buildings. India holding third rank in coal production in the world, As per the data available from the year 1950 to 2014 the average15,945 MT coal extracted from Indian coal mines, on the basis of coal production the expected geothermal energy extracted from abandoned mines, when taking proportionate value k equal to 0.25 and 1.0 minimum and maximum values of geothermal energy will be respectively 1992 MWt and 7917 MWt (Ministry of New and Renewable Energy).Therefore, average expected geothermal energy extracted from abandoned coal mines will be good sources of income.Many developed countries utilizes mine water for fish aquaculture for conservation, recreation, and economic development of the country and create jobs, increases the socio-economical life style of the local people surrounding mining region (Disouza et al., 2004)

Recovery of useful materials for industrial application:-

Many beneficial materials can be recovered after treatment of mine water for different industrial application e.g. different metals, saleable products, such as sulphur, sulphuric acid or sulphate, generation of electricity, Alkali recovery, such as $CaCO_3$, construction materials related to building such as cement and gypsum, useful fertilizer may be also recovered after treatment of mine water for agricultural uses. Recovery of ferrihydrite for paint industries also possible from mine water (Hedin, 2003).

Conclusions:-

This research paper shows the beneficial uses of mine water as water resources for different purposes. after extraction of coal and minerals, mine voids / pit lake can be suitably utilized for water storage all over world and storage water can be utilized to feed populated areas at the time of scarcity of water in different season and economical production of geothermal energy Although mine water contains many impurities compared with drinking and industrial water specification of different responsible agencies, mine water generally acidic in nature, low pH, contains iron, toxic heavy metals and potentially radioactive metals. So before utilization of mine water (MW) for different purposes required suitable treatment, such as aeration, chlorination, coagulation, pH adjustment, filtration, sedimentation etc for health and environmental safety. Reuse of mine water can solve scarcity problems of water supply, sanitation in surrounding mining area and provide many environmental, socio-economic benefits in development of Nation.

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