Impact of Mining on Ground and Surface Waters

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ABSTRACT

Water is an integral part in survival of living being both in way of direct consumption and maintaining the environment. The extent to which it is abundant or scarce, clean or polluted, beneficial or destructive, determines the quality of life to a large extent.

It is generally accepted that the total supply of water is constant in our planet, which has been estimated at 64.3 M km^2.

Though the estimated ground water is extremely large, a major share of it is deep sheeted, and is not exposed to hydrological cycle which has a self cleansing quality.

Whereas the shallow sheeted ground water is mostly tapped through wells, and get the chance of recycling, the deepsheeted water is reached, disturbed and contaminated by mining operation in the earth's womb. Mining of minerals, in one hand, is associated with problem of seepage causing disaster if left untamed, and on the other hand threatening the natural balance ecologically. Whereas, one seems to be more concerned with the former, the latter is generally left uncared for so long.

The impact of mining on ground water may be considered in terms of lowering of water table, subsidence, reduction of moisture content in soil and atmosphere, rise of temperature due to Albedo effect, disturbance on hydrological cycle, rainfall and climate, dust pollution, spontaneous heating and chances of fire in carbonaceous remains.

Similarly, so far as surface waters are concerned, the effects may occur in terms of impetuous and exodus evaporation, percolation due to subsidence, pollution due to mine water discharge, physical and chemical imbalance and effect on hydrological cycle, rain fall and climate.

All of the above impacts, directly or indirectly, act upon growth of flora and fauna in the locality resulting in a grave ecological imbalance. The silent hymns and chants of green bejewelled boulevard of nature and its juvenile deliquence would be gradually and respitely lost. One should always believe that "free lunch" is far from posibility. We loose one to get the other.

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INTRODUCTION

Out of all the natural resources available in the world, water assumes the most important place. It forms an integral part in survival of living being both in way of direct consumption and maintaining the environment. The extent to which it is abundant or scrace clean or polluted, beneficial or destructive, determines the quality of life to a large extent.

It is generally believed that the total supply of water is constant in our planet, which has been estimated at 64.3 M km^3.

There is an appreciable and adagio impact of mining on ground and surface waters. Rapid development of mining through out the world, with the galloping advances in science and technology is changing the shape of our planet giving rise to fundamental transformation of the environment in which water resources play crucial roles.

With the above in view, in this paper, an indepth discussion has been made to focus the impact of mining on ground and surface waters.

WORLD'S WATER RESOURCES

Untill today a number of estimates have been made of the world's total water resources[4]. Table 1, is presented to give an overall picture in this regard. The various elements mentioned in this table are those which comprise the hydrosphere, the aqueous envelope of the earth, including the oceans, polar ice, terrestrial and atmosphere waters. On the basis of above estimate the quantity of water per head comes to 25 000 crores of litre. However, the major share of this water is the saline water in ocean. The biggest source of sweat water is the polar ice. The remaining sources and terrestrial water which constitutes ground water, water in lakes, rivers and in soil moisture. The distribution of this water is shown in Table 2. From this table it may be noted that the major share of the terrestrial water is the ground water which is about 99.5 %.

In the earth's crust, there exists at a depth some impermeable layers of rocks. Water percolating from surface can go upto this place[2]. The depth of such impermeable layers, commonly known as floor, vary from few metres to even 10 km. However, in general this depth is 2 km.

The water on being obstructed by the floor saturates the overlying rocks upto certain height. The upper level or water saturated rocks is known as water table. The saturated rocks below water table and floor constitute the ground water.

The entry of water to ground table takes place through the pores of the rocks, cracks and crevices, fault planes and other communication channels. A portion of this water can be taken out by wells or may be pumped out from mines. But, a major portion remains thereat years after years. Recently, some Australian hydrologists have concluded that in Great Artesian Basin, the age of water is more than ten lakh years[5]. Such waters of similar age are also available in Indo-Gangetic plane of India. In certain areas waters of late Ice-age have been located. Such waters are known as "fossil waters".

Thus a sizeable quantity of ground water is locked up and generally left unapproached. However, the same may be tapped in emergency. In actual practice, it is the hydrological cycle which provides fresh water for meeting various needs on the planet.

One unique quality of water is to cleanse itself in the hydrological cycle. But, along with others, pollution by mining has become a problem almost in all surface bodies of water in the mining fields, the curse of which has already reached to some living beings.

WATERS IN MINING AREAS

Ground Water

Ground water flows into the mine workings as soon as excavations are made either on surface or below ground, due to natural flow through pores and permeable zones. Turbulent flow occurs in the joints, cracks and crevices connecting the mine-workings to water sources like water logged old workings, aquifers, aquitards or surface bodies of water. Table 3 shows some of such water sources.

Quantum of natural ground water inflow may be estimated on the basis of thorough study of hydrological parameters of the media through which ground water movement takes place. The study of hydrological cycle in the area is also important. This, in its turn, would include topographical study, deliniation of catchment areas, rainfall humidity, air temperatue variation etc.

Surface Waters

Surface bodies of water had been long associates of minig right from the inception. On one hand such water bodies pose threats of inundation to mine workings and on the other hand pumped out water from the mines when discharged into surface water may cause dreadful pollution. This is true for opencast and underground mines equally.

With the rapid growth of mining and exhaustion of minerals in easy geographical and geological zones, more difficult zones are now entered. Working under surface bodies of water is an example to cite. Working below rivers, lakes and even below sea is not considered very uncommon today[3].

Surface water bodies are now being classed as mentioned in Table 4 depending upon their vastness, appearance of flood, seasonal drying etc.

IMPACT OF MINING ON GROUND WATERS

Nature always tries to maintain its characteristic exotic beauty, along with the ecological balance which is sheer essential irrespective of wheather it is being felt or figured out by some body or not. Whenever mining is undertaken in an area the silent rhythm of nature is ravelled.

Due to mining surface contours are raped, drainage system disrupted, natural profile and surface reliefs are rocked, and so on. One of the major effects of mining is its impact on ground and surface waters. This, along with other disturbances, make the ecosystem to meet with grevious consequences.

The impact of mining on ground water may be considered under the following areas:

a) Lowering of water table
b) Subsidence
c) Reduction of moisture content in soil and atmosphere
d) Rise of temperatue due to Albedo effect
e) Disturbance on hydrological cycle, rain fall and climate
f) Dust pollution
g) Spontaneous heating and chances of fire in carbonaceous remains.

Similarly, so far as surface waters are concerned, the effects may occur in terms of following syndroms:

a) Impetuous and exodus evaporation in initial stages
b) Percolation due to subsidence and intermingled far flung extension of cracks and microcracks network.
c) Pollution due to discharge of untreated mine water and solid waste to surface bodies of water.
d) Physical and chemical inbalances.
e) Effects on hydrological cycle, rainfall and climate.

Lowering of water table

In the process of mining, when digging is undertaken, and when such activity extends below the water table, the working areas experience an inflow of water so much so that in some cases inundation takes place extending the danger of loss of life and property. Thus pumping becomes an integral part of mining. In normal process the water table represents a rest-level-surface with some hydraulic gradient depending upon the disposition of various types of rocks, their porosity, frequency of occurrence of breaks and bedding planes and the rainfall preceeding the period in question. This level of water will fall in the viscinity of a shaft through which pumping is undertaken. This will occur equally in all directions from the shaft, assuming similar ground condition. The level of water in the shaft is then known as the depressed or pumped water level, from the plane joining the water level in the ground around it is referred to as cone of depression. Such pumping operation in various points due to mining in region will cause resultant depression of water level. This is the cause of lowering of water table[1].

Subsidence

This is the local depression caused by taking out the rocks, mineral or even fluid from below the earth's surface. Subsidence occurence has been apprehended in many cases where excessive pumping of ground water is undertaken.

Apart from depression, subsidence includes various types of deformations in the overburden. Tension and compression archiry, shearing due to flexure of strata are likely

occurences due to subsidence.

Subsidence depressions, cracks, pits and trough, often induce, disrupt and divert the flow of water on earth's surface and therefore may adversely affect catchment areas.

The changes in the in-situ permeability around the cracking zone has a great bearing on study of impact on ground water.

Reduction of moisture content in soil and atmosphere

Along with other factors moisture content of soil is much related to the proximity of water table and extent of surface bodies of water. This also depends much on permeability character of soil. In coarse grained soil where voids are larger, the ground water flow becomes turbulent and soon after water has flown away the soil becomes dry. However, in case of entrapped air and other foreign matter the capacity of retention of moisture in the soil increases. Absorbed water surrounds the fine soil particles only and it is not free to move. Therefore, it causes an obstruction to free flow. But, such case is much overruled by development of cracks as mining proceeds. this invariably reduces the moisture content of the soil.

The moisture content in atmosphare is dependent, along with others, on available evaporating surface of bodies of water and moisture content of soil.

Thus, when both the above factors are affected by mining, the moisture content of atmosphere invariably reduces.

Rise of temperature due to Albedo effect

Rise of temperature is generally reported in mining areas where mining is continued for a long period. Though it is very difficult to explain the above rise and variations. But, one of the reasons of such variation is the Albedo effect. Right from the start of mining activities in an area trees are fell, herbs and sharbs are cleaned. As mining is continued there goes on considerable reduction in green cover, which has controlling effects on temperature due to evatranspiration. But the temperature depends on other factors also, like solar radiation, topography etc. Hence, any attempt to analyse the impact of mining only on temperature trend would be inconclusive.

Disturbance in hydrological cycle, rain fall and climate

It is difficult again to analyse the impact of mining only on hydrological cycle, rainfall and climate, though experience world over is, on disturbances in hydrological cycle, rain fall and climate. As stated earlier green cover declines due to mining over the area. Plants, no dubt, play a significant role in the hydrological cycle through evapotranspiration and contribute greatly to the atmospheric water leading to precipitation. Still, the later also depends on other factors like solar radiation, wind velocity and direction and topograhpy etc. Mining over a small area may not have any impact on the point under question, but large scale mining over wider areas in the country would invariably affect in hydrological cycle. However, afforastation to compensate the deforestation due to mining operation would nullify the impact, if any.

Dust Pollution

The amount of air borne dust in atmosphere depends on air velocity, humidity, size, shape and weight of dust particles.

Since dust is invariably produced due to mining and because of increased dryness of soil and ambient air, dust problem becomes more acute.

The dust or suspended particulate matter (SPM) specially 5 micron size or below, is a major air pollutant which can cause pulmonary afflictions, like silicosis, pneumokroniosis and others.

Spontaneous heating and chances of fire in carbonaceous remains

Coal and carbonaceous material are succeptible to spontaneous combustion and heating, which ultimately lead to fire with emission of smoke and noxious gases causing serious atmospheric pollution. Continuous and perpetual fire of such nature would affect moisture contents in soil and air and indirectly affect, adjacent water bodies.

All the above areas are interrelated and interdependent and combined effect of all of them results in degeneration and deprovation of flora and fauna of the region which again in its turn exaggerates some of the above effects in tortuous routine. The rebuttal repartiation and valediction to natures sortical scene along with ecological intrigue would stop the vibrant assortment of plants and arrey of life.

Impact of mining on surface waters

So far as surface waters are concerned, the effects of mining may occur in terms the following syndroms:

Impetuous and exodus evaporation at initial stages

Impetuous and exodus evaporation occurs in the initial stages when the appreciable effects of mining with associated environmental imbalance ensues. Smaller ponds, ditches even

seasonal nallahs have been seen drying up in a shorter duration than normal. However no major work has been done to study the real cause of such impetus and exodus evaporation.

Percolation due to subsidence developing network of cracks and microcracks

Percolation of water occurs due to subsidence and intermingled, far flung extention of network of cracks and microcracks. This is responsible for loss of water of surface bodies, Migration proceeds in a direction parallel to bedding planes also.

Flow of water below the surface is proportional to the square of the void ratio. Lower the percentage of fine parlicles, higher is the rate of percolation.

Pollution due to discharge of mine water

Pumped out water from mine workings

Both in case of opencast and underground method, mine water is discharged either into a river flowing nearby or any other surface body of water. Though in some cases the water may be fit for such discharging, but in many cases it is not so. The water may contain suspended solid and other pollutants.

Liquid effluent from mining areas

Consequent to mining other sources of water pollution are effluent from colony, industrial areas, surface run off passing through coal or mineral piles and overburden dumps (in case of opencast mines) and storm water. All such waters discharge in a surface water body thereby polluting it to the extent depending upon the pollutant content in such sources.

Effluent from colony

Liquid effluents from amenity centres and residential houses (particularly from toilets) are expected to be highly polluted and in general potential source of health hazards, unless treated in oxidation ponds and aeration tank etc, causing zelo pollution.

Effluent from industrial areas

These are expected to be contaminated with grease, oil and suspendes solids.

Surface run off passing through coal/mineral piles and overburden dumps

Surface run off caused by precipitation from coal piles and OB dumps may carry suspended as well as dissolved solids. This contamination may cause heavy siltation in rivers and nallahs, if discharged untreated. Further, OB dump washing may contain high nitrate due to residual explosive end products. This high nitrate may cause surface water pollution resulting in diseases like "methaenoglobinemia" in babies aged less than six months and gastro intestinal ulcers in adults.

Storm water

Surface run off in the leasehold area would cause heavy soil erosion, and siltation in rivers.

Impact of polluted water

The polluted water may have objectionable odour and colour. It may also be acidic, toxic and highly turbid, making them completely unfit for drinking or other use. Sometimes

they may contain microorganisms which are hazardous to health. The impact of such polluted water may be as follows:

- may cause different water borne diseases
- unsuitable for animal husbandry, revegitation and human or animal use
- high turbidity, oil and grease film may not allows adequate oxidation of surface water
- high turbidity may prevent entry of sunlight to promote photo-synthesies of aquatic plants. So, polluted water may affect aquatic life. Water quality analysis results in a mining area in India is shown in Table 5. This is quoted as an example of impact of mining on surface waters.

Physical and chemical imbalance

In natural state every area maintains a physical and chemical balance. In physical balance the landscape and the natural drainage system assumes the most priority position. Due to mining, the land damage takes place directly in case of open-pit mining and by subsidence in case of underground method of mineral extraction. In either casses the land scape is damaged and contours reshaped due to which drainage system suffers. This leads to serious problem in respect to further land degradation. A number of mines occur in forest areas, which means damage to forests alongwith. This indirectly initiates an unending chain of physical imbalances.

The chemical constituents of soil and dissolved minerals in the regional water maintains a chemical balance, which is disturbed due to mining. This is due to breaking and degradation of land, derangement in drainage system and others. Such imbalance in its turn affect local flora and fauna which experiences a haulted growth and may head towards extinction.

Effect on hydrological cycle, rainfall and climate

Both immediate and ultimate effect of mining is generation of eco-system imbalances, which in its turn affect the hydrological cycle, rainfall and climate. Reduction of moisture content in soil and air, disruption of drainage system consequent upon land ravelling due to mining, deforestation etc. will be responsible for erratic hydrological cycle, inpredictable rainfall and uncompromisable climate for hymns of nature to continue.

All of the above impacts, directly or indirectly act upon growth of flora and fauna. Sometimes mines are situated in and around forest areas, where forest flora and fauna are damaged.

So far as forest flora is considered, the most common associates in Indria are shown in Table 6. Similarly forest fauna common in mining regions in India is indicated in Table 7.

Loss of flora and fauna in a large scale due to mining results in a grave ecological imbalance.

CONCLUSIONS

For upgradation of the quality of human life winning of minerals from the womb of earth cannot be bypassed. But, in doing so, firstly the land is damaged. The next in the list is production of a pendemonium state in the ground and surface waters. The damage done to these, both physically and chemically, is to the extent that the premining eco-systems of nature are ravelled to incurable imbalances. As a result, the silent hymns and chants of green bejewelled boulevard of nature and its juvenile deliquences are gradually and respitely lost. One should always believe that "free lunch" is far from possibility. We loose one to get the other. A bold line environmental management plan to save the situation is strongly recommended and in this, fighting against the spurious impact of mining on ground and surface waters assumes much prior position.

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Table 1. World's water resources

Elements in the hydrosphere	Volume M km^3	Percentage
World ocean	1370	93
Polar ice	24	2
Terrestrial waters	64	5
Atmosphere	.013	0.001

Table 2. Terrestrial water distribution

Elements in the terrestrial Waters	Volume M km^3
Ground water	64
Lakes	0.23
Rivers	.0012
Soil moisture	.082

Table 3. Sources of mine water

Sources	Bodies
Surface waters	Sea, lakes, swamps, clay deposits
cavernous carbonate rocks	usually happens in lime stone mines.
Fault conduit	Flow from primary paths
Man-made sources	Quarries & goaves - waterlogged,
Subsidence fractures	connection to water bodies.

Table 4. Classification of surface bodies of water

Class	Description	Examples
Catastrophic bodies of water	Where water is unlimited & un-controlled	Sea, Ocean
Major bodies of water	Where water body is limited but very large bodies of water where flood may come.	river, lake water reservior
Limited bodies of water	Where water body has limited volume & cannot cause any flood in intensive area.	Nallahs, ponds.

Table 5. Water quality analyses results:

Sampling points	Results
Ponds	Disolved solids and iron content exceed limits of IS 10500-1984. Disolved solids predomenently constitute ions of chlorides & sulphates.
Nallah Water	Yellow colour due to excess iron and zinc content. The content. The BOD value is high. Presence of sulphates exceeds the limits of IS 10500-1984.
Well water	Excess iron content. Level of fluoride concentration not conforming to IS 10500-1984.
Mine Discharge Water	Light yellow colour due to excess iron content presence of phosphate. Low BOD & volatile matters

Table 6. Forest Florav in a mining region in India

Area type	Flora type
Near depressions & nallahs	Sal and its common associates like Terminalia alata, Diospyros embryopleris, syzgium cumini, emblica officinalis, Buchanania latifolia and Dillenia pentagyna etc.
Hill slopes	Terminalia alata, Diospyros melanoxylon, Anogeissus eatifolia, Dalbergia sisoo and Plerocarpus marsumpium etc. Scattered clumps of Dendrocalamns stricuts, indigofera pulchella. The main climber is combretum decandrum etc.

Table 7. Forest fauna in a mining region in India

Class	Fauna
Wild animals	Indian fox, jackal, common mongoose stripped hyaena, wolf, common langur, flying fox etc.
Birds	Peafowl, jungle fowl, common spur fowl, gray hormbills blue winged teal, whistling teal, collon teal etc.
Reptile	Russell's viper, krait, Dhomna, Dhanda etc.