Drastic Model for Pollution Potential Studies of Groundwater in Mining Belt : A Case Study of Koira Block, Odisha,India

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Abstract-*Potential for ground water contamination depends on the physical characteristics of the area, the chemical nature of the pollutant, the rate, frequency etc. The hydrologic environments that cause pollution include the interdependence of factors such as permeability, adsorption, hydraulic gradient, position of water table, topography, aquifer media and distance from contamination source.The mining area is moderately vulnerable to pollution at present (DRASTIC INDEX-120) and it may be enhanced due to change in parameters in future. It is also felt that prediction and evaluation of pollution of the subsurface environment and planning remedial actions at existing sites may be useful for placing and designing new land based waste treatment or disposal facilities.*

Keywords*-*Aquifer, Hydrogeology; Artificial Recharge; DRASTIC

I. INTRODUCTION

Ground water is an economic resource and more than 85% of the public water supplies are obtained from wells (Raghunath, 2007). National reliance on ground water has increased dramatically over the past few years in India. The potential for ground water contamination depends on the physical characteristics of the area, the chemical nature of the pollutant, the rate, frequency etc. The hydrologic environments that cause pollution include the interdependence of factors such as permeability, adsorption, hydraulic gradient, position of water table, topography, aquifer media and distance from contamination source (Raghunath, 2007). Although contamination due to man has occurred for many years, only in past few years has the nation become aware of the dangers of ground water contamination. There is a need for understanding pollution as a first step for its evaluation and control.

The fast pace of urbanization, a direct consequence of population growth, is exerting tremendous pressure on our water resources. Urban areas are fast becoming a vast concrete jungle where the ecosystem is highly artificial and over-exploited. Unscientific and haphazard development of urban areas is causing irreparable damage to our ground water resources which could lead to major water crises in the near future. Ground water pollution related works has been carried out by many workers in different parts of our country (Subba Rao *et al.,* 2007), (Singh and Lawrence, 2007). DRASTIC model has been applied in different area like Vallar Basin in Tamil Nadu (Jayakumar, 1996) and Rewa in M.P (Mishra *et al.,* 1996) and Rahman (2008) and Tirkey*et al.,* (2013) and accordingly remedial measures have been taken from pollution point of view. Review of studies relating to pollution of ground water reveals that ground water pollution occurs in Berhampur area. Nanda (2003) reported that quality wise, the water of both dug wells and borewells are not up to the standard as prescribed by (ISI, 1983). In certain areas, the nitrate content is more than the permissible limit. The dug well water is of inferior quality than the bore well water. It is reported that the Berhampur city is not free from water pollution. Ground water is also not safe for drinking in some areas (Prasanna *et al.,* 2008). Roy *et al.,* (2003) has mentioned in his report that high concentration of NO3 in ground water occurs at some places. Keeping the above facts in view, an attempt has been made to evaluate the vulnerability of ground water to contamination using DRASTIC method.

The present area of study is Koira block of Sundargarh district of ofOdisha.The mining activities in Koira block is an ongoing process operated by Steel Authority of India Limited (SAIL), Tata Iron and Steel Company (TISCO), Orissa Mining Corporation (OMC) etc. for exploitation of iron and manganese ores and bauxite. The ores are being exploited for the last 4 decades. Some of the mines of SAIL and TISCO are completely mechanized and since then the ore production has increased significantly. The iron and manganese ores are restricted to hills and valleys respectively. These structural hills and valleys which once acted as groundwater recharge zones are being lost by mining activities. Borehole records of the mines show that the groundwater table has been lowered significantly in the last 20 years. Consequently, the local dug wells which were once perennial, now become dry by March each year. The groundwater depletion in the mining belt may be due to decrease in groundwater recharge potential which is attributed to excavation of iron ores and rejects from the mines in addition to the deforestation caused by extensive opencast Mining.

To study the environmental effects on groundwater regime due to mining activity in Koira block, 10 dug wells located near Koira, Barsua, Malda, Gouna, Kasira, Ranisal, Kalta and Tantra villages surrounding the mines were selected for monitoring. The wells at Kalta, Koira&Barsua have been contaminated with excessive silts flowing in through mine discharges. The dug well of Barsua is found to be contaminated with diesel allegedly seeping from adjoining areas where washing of mine machinery is done. These wells are considered to be hydraulically connected to the mines. Since no water is drawn from these three wells for use by villagers, water level fluctuation in these wells directly reflect the change in water table as a consequence of mining. The water table levels in these wells were recorded for 5 consecutive years since 2012. The groundwater and surface water which enters the mine during mining operations is collected in the lowest pit from where it is pumped out to the nearby streams. The fine silts and clays in these waters silt up to the drainage channels, thus reducing infiltration and permeability. The silted mine water have also seeped into the dug wells in the adjoining areas. There is a need to increase the infiltration rate in this belt. The mine water should be thoroughly desilted before being released into the local streams. This measure will also reduce pollution of groundwater by siltation. The mine waters containing high amount of silt and wash of diesel operated mine machinery are stored in the lowest pit of the mine before being pumped out. Instead, these water need to be stored in impervious containers, be thoroughly desilted and oil residues filtered out before being released into local channel.

II. MATERIALS AND METHODS

All the available data on geology, hydrogeology and other related data were collected from different agencies / publications and were suitable processed. Topographic map of Survey of India and thematic maps on litho-logy, structure, drainage, geomorphology generated from satellite data were used. Field reconnaissance survey was conducted to generate data related to geology and hydrogeology. All the above data have been integrated to understand the hydro geological setting of the area which forms the basis of evaluation of pollution potential and basic framework of DRASTIC model. DRASTIC model of evaluation of ground water pollution potential has been used. Drastic is a standardized system to evaluate ground water pollution potential using hydro geologic setting. A hydro geologic setting is a composite description of all the major geologic and hydrologic factors which affect and control ground water movement into, through and out of an area. It is defined as a mappable unit with common hydro geologic characteristics and as a consequence, common vulnerability to contamination by introduced pollutants. From these factors, it is possible to make generalizations about both ground water available and ground water pollution potential. Information on the parameters including the depth to water table in an area, net recharge, aquifer media, soil media, general topography or slope, Vadose zone media and hydraulic conductively of the aquifer is necessary to evaluate the ground water pollution potential of any area.(Table 1). These factors form the acronym DRASTIC. (Aller *et al.*, (1987).

Table1 : DRASTIC chart

Parameters	Weight
Depth to water (D)	5
Net Recharge (R)	4
Aquifer Media (A)	3
Soil Media (S)	2
Topography (T)	1
Impact of vadose zone -I	5
Hydraulic Conductivity of the Aquifer (C)	3

DRASTIC Index has been computed taking into account the ranges and rating of different parameters outlined by Aller *et al.*, (1987) using the following expression.

D.I. = Dr. Dw + Rr. Rw + Ar Aw + Sr Sw + Tr. Tw + Ir. Iw + Cr.Cw.

where,

r = rating of the parameters w=weight of the parameters

The higher the DRASTIC Index, the greater the ground water pollution potential. The DRASTIC Index provides only a relative evaluation tool and is not designed to provide absolute answer.

Colour codes for DRASTIC Indices	
Less than 79	Violet
80-99	Indigo
100-119	Blue
120-139	Dark Green
140-159	Light Green
160-179	Yellow
180-199	Orange
200 and above	Red

III. RESULTS AND DISCUSSION

The DRASTIC Index (DI) has been evaluated for Koira block taking into account the ranges and rating of different parameters outlined by Aller *et al.,* (1987) (Table-3).

Table3 : DRASTIC chart for the Koira block Area (Shallow water table condition)

Parameters	Range	Weight	Rating	Number
Depth to water table	1-8 m	5	8	40
Net Recharge	80-110 mm	4	3	12
Aquifer media	Weathered Metamorphic	3	4	12
Soil media	Clay loam	2	4	08
Topography	0 -2 %	1	10	10
Impact of Vadose zone	Metamorphic rocks	5	4	20
Hydraulic Conductivity	1.5 to 5 m/day	3	6	18
	DRASTIC INDEX			120

From the above discussion it is clear that the mining area is moderately vulnerable to pollution at present (DRASTIC INDEX-120) and it may be enhanced due to change in parameters in future. It is also felt that prediction and evaluation of pollution of the subsurface environment and planning remedial actions at existing sites may be useful for placing and designing new land based waste treatment or disposal facilities. Though it is thought that the model used to make such prediction is based on the assumption that the system behaves ideally but a variety of factors such as the model, pollution transport parameters and the geometric uncertainty etc. introduce uncertainty into the model prediction. Therefore, it is suggested that the other uncertainty analysis techniques such as Monte- Carlo Analysis Modelling for groundwater pollution may be applied in such areas to know the transport mechanism and concentration of pollutants in a more deterministic way (Bobba et al. 1995).

IV. CONCLUSION

Ground water is an economic resource and more than 85% of the public water supplies are obtained from wells. The potential for ground water contamination depends on the physical characteristics of the area, the chemical nature of the pollutant, the rate, frequency etc. The hydrologic environments that cause pollution include the interdependence of factors such as permeability, adsorption, hydraulic gradient, position of water table, topography, aquifer media and distance from contamination source. Drastic is a standardized system to evaluate ground water pollution potential using hydro geologic setting. From the above discussion it is clear that the mining area is moderately vulnerable to pollution at present (DRASTIC INDEX-120) and it may be enhanced due to change in parameters in future.

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