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Research Article

EVALUATION OF GROUND WATER POLLUTION POTENTIAL USING DRASTIC MODEL: A CASE STUDY IN BERHAMPUR CITY, ORISSA

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ABSTRACT
Water is the elixir of life. It is the basic natural resource, a basic human need and a precious national asset. It is our duty to conserve and judiciously use the lifeline of civilization – Water. The quality of ground water is as important as its quantity. The present paper discusses on the vulnerability of ground water to contamination in water stress Berhampur city, Odisha using the DRASTIC method of evaluation. The study reveals that the ground water of the area is moderately vulnerable to pollution from surface sources.The Pollution Potential Index is 120.

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

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 NO_3 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. This will be of immense use in sustainable development of ground water in water scare Berhampur city of Orissa.

Study Area Profile
Berhampur, one of the important city of Orissa, situated on the east coast of India, is popularly known as "Silk City". It lies between 19^0 15' to 19^0 20' N latitude and $84^0$45' to $84^0$50' E longitude and falls under the Survey of India Toposheet No. 74 A/15 (Figure 1).

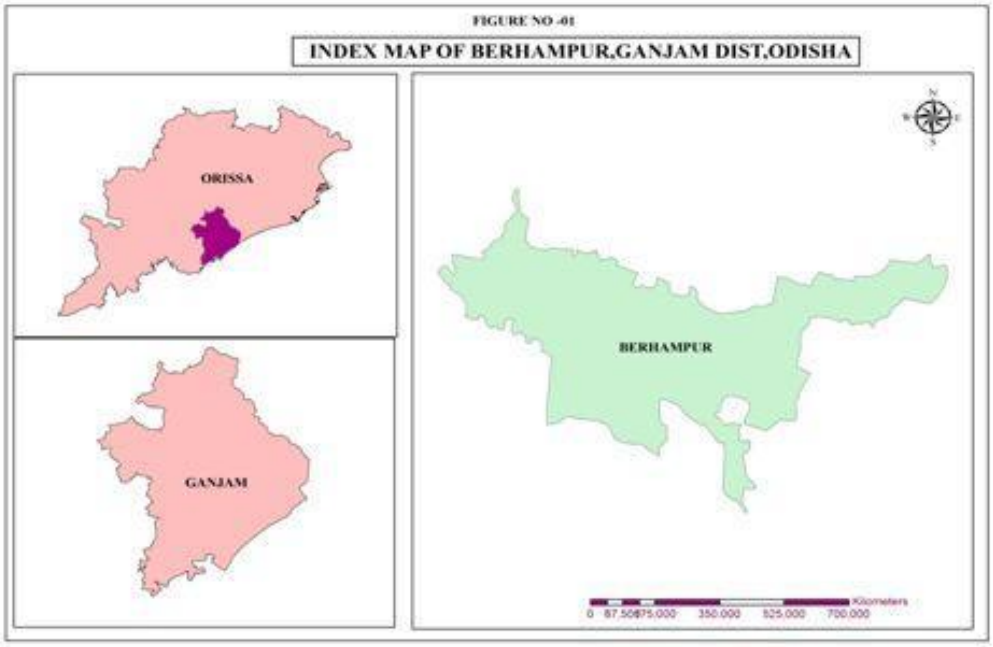

Figure 1: Index map of Berhampur Area

It is well connected to other parts of the country by road and railways. It is a fast growing city in South Orissa. The present population touches about 4.5 lakhs. The area falls under the humid to sub-humid tropical climate region. The average annual rainfall is 1350 mm. Physiographically, the study area forms a part of the eastern coastal plain region. This coastal plain is a low-lying tract between the Eastern Ghats and the coast line, which has an elevation of about 20m above mean sea level (MSL). Surya Nadi and Sapua Nalah drains the study area (Figure 2) the texture of the soil varies from sandy loam to sandy clay loam with depth. The drainage density in the study area is low.

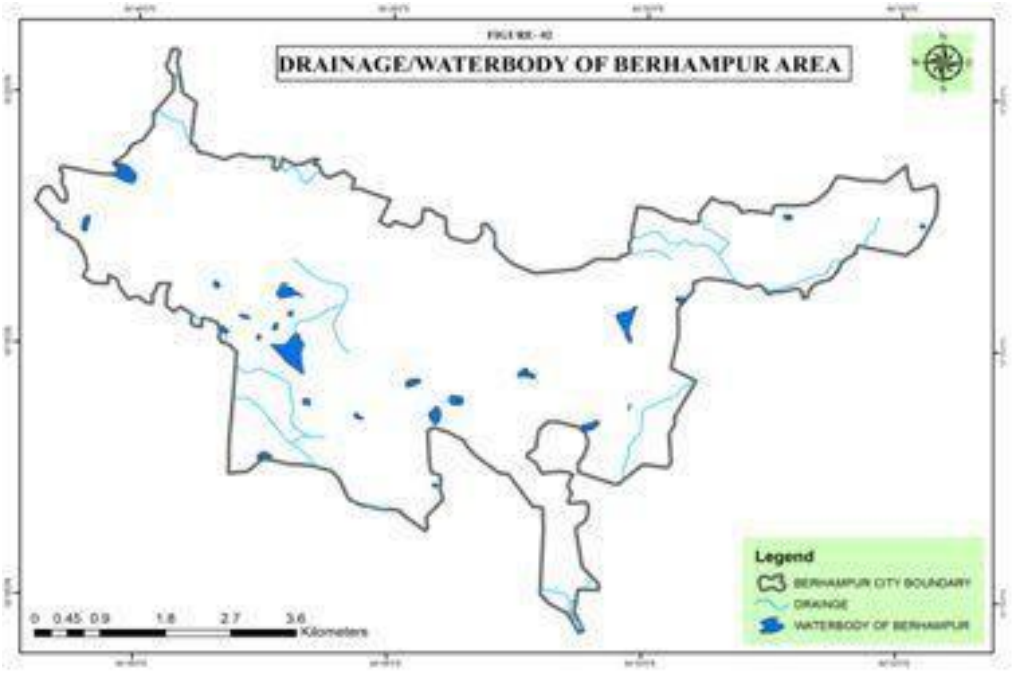

Figure 2: Drainage/Water body of Berhampur Area

Vital Facts Regarding Berhampur City

- There is little area in the city which is either free from building or some sort of solid cover.
- Natural drainage is either partly filled up or chocked.
- Due to the pressure on land, even wet and low-lying area that are vital for the drainage of the land are being utilized for constructional purposes.
- There is no standard norm relating to well spacing, depth and draft (Sahu, 2006). Multiple bore wells rampantly dug have depleted the water table.
- Channel aggradations are a common form of environmental degradation by human activities.
- Urban flooding has become a chronic hazard in the city during rainy season.
- Geoscientific inputs (Geological, Hydrogeological and Geomorphic data) of the ground are not taken into consideration for planning the town.
- Construction activities any where and every where without regard to natural drainage/ ground condition add to the problem.
- People are in the habit of throwing their domestic refuses in open spaces / on roads and ponds.
- There is no master sewage system and the sewage water generally seeps into the soil, thereby polluting the ground water.
- The city is vulnerable to cyclonic hazards. Berhampur has witnessed the super cyclone in 1999.

Water Demand and Supply Ratio

- Its water supply need is met from both surface water and ground water. Berhampur needs 56 MLD of water for domestic purposes. Water supplied is 35 MLD against the demand of 56 MLD. It is evident that water scarcity is acute during summer. Water that is now supplied to the Municipality area through pipelines comes from two different sources located outside municipality area i.e. a) Dakhinapur reservoir b) Rushikulya collection well.

The following are the natural consequences of damages caused to the urban water system.

- There is very little ground water recharge in urban area since bulk of the rain water can not seep into the predominantly sealed ground and there is considerable surface run off. This leads to a shortage of ground water during the summer time.
- Ground water levels decline considerably due to both excessive draft through tubewells / borewells and low recharge.
- The old water harvesting structures (tanks) of the city are loaded with silt and clays which prevents the process of recharging ground water.

Geology and Hydrogeology

The study area forms a part of the Eastern Ghats Group of rocks of Precambrian age. Granitic Gneiss is the dominant litho member.

The area belongs to the Pre-Cambrian Crystalline Ground Water Province. They are considered as hard rocks with negligible primary porosity and permeability. Good aquifer system exists only when secondary porosity is developed due to weathering and fracturing.

Ground water occurs in weathered zones at shallow depth and in fractured zones at deeper level. Ground water occurs under water table condition in the weathered zone and semi-confined to confined state in the fractured rocks depending upon the depth. The potential water yielding fracture zones are generally restricted within a depth of 60 mbgl. The groundwater prospects in and around Berhampur is shown in Figure-3.

The hydro geological setting of the study area is characterized by gently sloping topography. The different geomorphic units are shown in Figure-4. Depth to water table varies for 1m to 8 m. Weathered metamorphic rocks of Eastern Ghats Group forms the aquifer. The soil texture is sandy loam/ sandy clay loams.

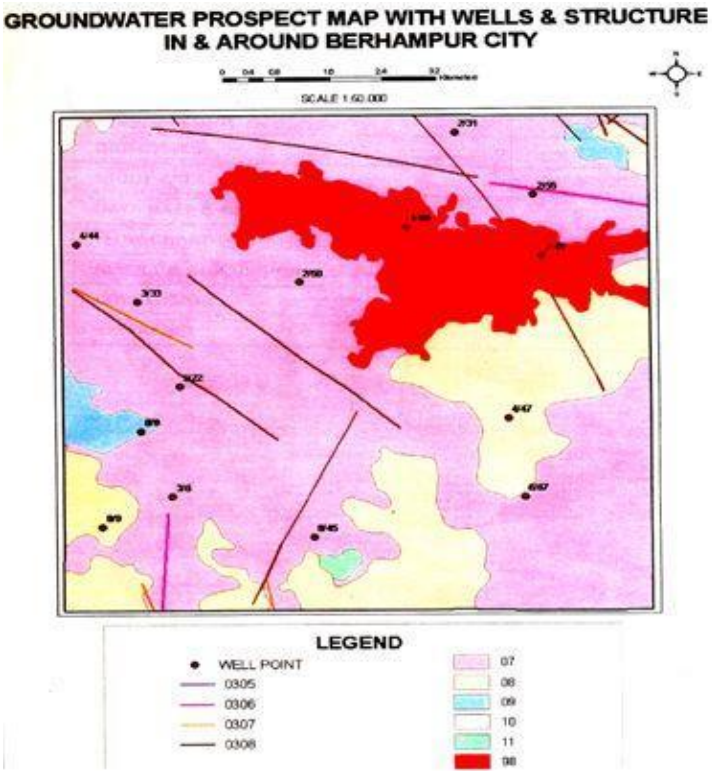

Figure 3: Ground water prospect map of Berhampur Area

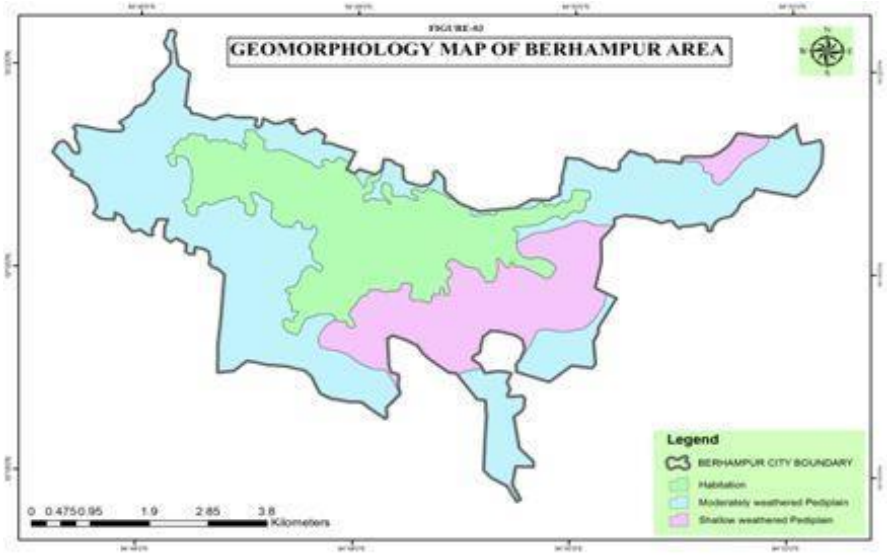

Figure 4: Geomorphology map of Berhampur Area

MATERIALS AND METHODS

Date Used and Methodology

All the available data on geology, hydrogeology and other related data were collected from different agencies / publications and were suitable processed. Topographic map (74A/15) of Survey of India and thematic maps on lithology, 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

basic framework of DRASTIC model. DRASTIC model of evaluation of ground water pollution potential has been used.

Drastic

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 These factors form the acronym DRASTIC. (Aller *et al.,* (1987)

D- Depth to water table
R- Recharge (Net)
A- Aquifer media
S- Soil media
T- Topography (slope)
I – Impact of the vadose zone
C- (Hydraulic) Conductivity of aquifer

The relative ranking scheme uses a combination of weights and rating to produce a numerical value, called the DRASTIC INDEX (Table-1).

Table1: Assigned Weights for Drastic Features

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

RESULTS AND DISCUSSION

The DRASTIC Index (DI) has been evaluated for Berhampur city taking into account the ranges and rating of different parameters outlined by Aller *et al.,* (1987) (Table-2).

Table 2: DRASTIC chart for the Berhampur 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/ Sandy 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**

The Pollution Potential Index (i.e. DRASTIC INDEX) for Berhampur is 120 for which the colour code given is Dark Green. The ground water of the area is moderately vulnerable to contamination from surface sources at present and it may be enhanced due to change in hydro geological parameters in future.. Mention is made of the incidence of ground water pollution in the area, as gleaned from literature available on the subject (Nanda (2003), Roy *et al.,* (2003), Prasanna *et al.,* (2008). The cause of ground water pollution is anthropogenic. Ground water of this area contain high concentration of Nitrate and Sulphate where the wells are very closely located to septic tanks and sewage water. Disposal, without proper treatment, of sewage (Municipal and Domestic wastes), has been the cause of deterioration in the quality of ground water, adversely affecting the water supplies for municipal and domestic uses.

Since the Berhampur city is growing by leaps and bound into a sprawling urban complex; urban expansion, growing industrial activities and urban effluents increase the incidence and risk of pollution of ground water. With quality of ground water seriously threatened due to increasing source of contamination, it may not be possible to sustain long-term growth and development of urban area without hazards to public health unless remedial measures are taken in time. To protect the ground water resource against pollution, a water quality monitoring programme i.e. a scientifically designed surveillance system of continuing measurements, observation and evaluation is necessary. A comprehensive land and water management policy for the Berhampur city involving city planners, engineers in the area of Hydrology, Earth Scientists, Land use experts, Environmentalist, Social Scientists, Lawyers, Politicians and the general public is urgently needed to avert or minimize the anthropogenic hazards in future.

Rejuvenation of natural drainage systems, desiltation of ponds and streams, preservation of wet and low-lying lands and roof top rain water harvesting, proper method of waste disposal and maintenance of drainage system are some of the important steps towards the protection of ground water sanctuary. The regions in and around the Berhampur city need artificial recharge of ground water through rain water harvesting for sustainability of ground water quality in the wake of its excessive withdrawal. Building codes of cities need revision to make roof top rain water harvesting mandatory for all new construction. Construction of various rain water harvesting structures in public places such as parks could enthuse the public.

Public participation is at the root of success of any policy and hence proper co-ordination between government departments involved in water resources management, NGO groups and the public is also a great need. Proper information and education should be imparted to the people about the importance of ground water in the water stress Berhampur city. Instituting awards for innovative, practical and optimal methods of water use should encourage the public to practice water management.

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