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PRESENT SCENARIO OF GROUNDWATER TABLE IN SALINE PRONE AREAS OF PURBA MEDINIPUR IN WEST BENGAL, INDIA

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ABSTRACT

Accurate estimate of groundwater budgeting requires accurate identification of the locations containing freshwater especially if the concerned area is saline prone. Current trends everywhere show that surface water available is low due to low amount of rainfall and other reasons. People are more inclined to use groundwater for irrigation use, domestic use and industrial purpose. According to Ghyben-Herzberg principle, if the groundwater level declines one unit then the seawater intrusion will intrude around forty units towards the inland areas. Therefore the depth interface between the freshwater and saline water will also be shifted towards the inland. For this reason, it is really challenging to determine the present groundwater scenario and predicting groundwater potentials (GWPs) in coastal areas of Purba Medinipur. Here groundwater level is declining day-by-day. But the natural replenishment of groundwater is very low. Nearest rivers Haldi and Rupnarayanpur are less contaminated with seawater intrusion as these rivers are located at eastern coastal parts. Gross drafts from these rivers are becoming very low. Contemporary gross draft from groundwater is enhanced. So it is necessary to determine GWP of study area. Various equations and numerical modelling techniques are available to determine groundwater flux. In this study an attempt has been made to assess the present scenario of groundwater tables in saline prone areas alongwith identification of best method to estimate GWP.

KEYWORDS

Groundwater, Seawater, Salinity, Coastal area, Groundwater potential.

1. INTRODUCTION

Indian Coastline is very large. It is of 7520 km in length. Mainland coastline is of 6100 km length and island coastline is of length of 1420 km. Coastal India greatly spans about South -West Coastline alongside Arabian Sea to the coast-line of Gulf-of-Kutch. In the West side it is stretched from the Gulf of Khambhat, and through Salsette island in Mumbai alongside Konkan and south wards across Raigad area and thereafter through Kanara area and further along through Mangalore area and alongside Malabar area through Cape-Comorin area in southernmost area of South- India with coast-line alongside Indian Ocean, and through Choolamandalam or Coromandal Coast. The coast -line on South- Eastern section of Indian Subcontinent alongside Bay-of Bengal through Utkala- Kalinga section extends till the eastern- most turn of shore- line near Sunder-bans of India's eastern coast. There are, obviously, various long beaches and beautiful springs here, plus attractive sea resembling Arabian Sea. Purba Medinipur is located in eastern coastal area of India. Latitude and Longitude of Purba Medinipur are 21°56'30.50" N and 87°46'17.26" E. Contai is located south portion of Purba Medinipur. Egra is located in the west side of Purba Medinipur. Digha is located south west portion of Purba Medinipur. All these locations are very near to Bay of Bengal. These areas are affected by sea water intrusion. Haldi River is the major river in Purba Medinipur which is

originated close to Bay of Bengal. The water quality is deteriorating day-by-day due to saline water intrusion which makes it unfit for domestic, industrial and irrigation use.

Figure 1: Map showing location of Purba Medinipur

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2. INFERENCES FROM PREVIOUS RESEARCHES ON SALINE PRONE AREAS AND GWP

Abadi and Shamma, 2014 showed that due to the drought conditions in Iraq and also water policies in adjacent countries and the need for food security there was necessity to assess groundwater resources. In their study they had showed the groundwater availability zone with modern techniques. They had used GIS to determine their findings. They had mapped the GWP maps by ArcGIS. The GWP maps were finally established using existing abstraction rates of related existing wells.

Condon and Maxwell, 2015 studied factor of topographical features on ground-water fluxes plus water table (WT) depths crosswise the adjacent United States. Mansouri and Mezouary, 2015 tried to develop aquifer artificial recharge technique. This system was analyzed on the basis of numerical modelling technique. Zeinolabedini and Esmaily, 2015 tried to determine the best area of GWP in Baft city of Kerman in Iran using GIS taking parameters like precipitation rate, slope factor, land cover, vegetation, fault, and lithology.

Ashraf et al., 2018 attempted to characterize the aquifer. They tried to calculate GWP in sedimentary rock deposit. Electrical resistivity along with typical drilling techniques were applied to get the desired result. They developed sub-surface soil contours were determined for finding suitable site for tubewell construction purpose. The surveys were taken place using Terrameter (ABEM) L. S. System. Such results were investigated using 2D – resistivity – inversion – program (RES-2D-INV) software. Potential zone was identified using resistivity method. The study area was Kampung Bukit Kerek in Kedah. Lee et al., 2019 showed that data mining analysis techniques have been developed in various field. That could be applied in complex field like GWP in South Korea. They had successfully estimate GWP in South Korea.

A few researches were conducted in India too. Hutti and Nijagunappa, 2011 tried to show that systematic plan of ground-water exploration using recent techniques was crucial for proper usage and thereafter management of such valuable but finch natural resource. Preeja et al., 2011 identified GWP zones of River Basin - Ithikkara (IRB), Kerala. They had done groundwater studies using GIS methodology. The composite type maps generated, was more categorised according to spatial deviation of GWP. According to them there were four categories of GWPs. Those were - poor, - moderate, - good and - very good.

Agarwal et al., 2013 attempted to show that the sustainable growth and subsequent management of ground-water source requires specific quantitative evaluation derived from scientific principle plus modern practices. Here, GWP zone was critically delineated by remote-sensing, geographical – information – system (GIS) along with multi – criteria – decision – making – techniques (MCDM) at Unnao of Uttar Pradesh. Analytical – network – process (ANP), here, was a process that prepared it probable for dealing systematically, which included popular analytical – hierarchy – process (AHP) as special-case.

Ali et al., 2015 had examined the movement of groundwater on bed rock which was governed by many factors viz. Lithology, topography, geological structures, fracture density, aperture and secondary porosity connectivity. They had studied Bharathapuzha river basin, Cochin. Bore wells of medium to high yield tapping the deep aquifer zones were mainly situated along lineament intersections. Kumar et al., 2016 had identified potential groundwater zone applying electrical resistivity method and lineament pattern in the dry watershed of Uppodai, Tamilnadu. They had estimated the variation of groundwater depth. They had also identified the factors on which GWP varied. Kushwaha and Goyal, 2016 had applied GIS based methodology to determine groundwater flux, velocity component, amount of groundwater pre-monsoon along with post-monsoon period. With the help of these obtained data groundwater budgeting they had done.

Srinivas, 2017 identified GWP zone applying RS and GIS software. The different thematic maps were boundary, drainage, digital elevation model (DEM), slope factor, drainage density, soil, lineaments, land – use land – cover, rainfall maps. The DEM has been generated from the 20 m contour interval contour lines derived from SOI toposheets, The Slope map has been prepared from DEM. Maity et al., 2017a saw that the surface water was less in amount in Purba Medinipur district, West Bengal. So utilize of groundwater extraction is becoming more and more due to increased

population, industrialization, urbanization. Due to over exploitation of groundwater, seawater intrusion is taking place in that district. To support this various field studies related to sub soil characteristics, groundwater quality parameter assessment had been carried out. Piezometric surface of groundwater at various seasons had been also developed. It had also been calculated the safe yield from vertical and qanat well in that locations. It had also been concluded from the journal that vertical riser coupled with quanta well were suitable for that district. Maity et al., 2017b experimentally did few analyses on the GWL effect due to sea water intrusion at 24 Pargana coastal belts.

Lakshmi and Reddy, 2018 used techniques and methodology which they applied for identifying GWP zones using GIS and remote sensing. Various parameters were applied to determine GWP. The parameters that were used for controlling groundwater zones were soil, land – use, drainage density, land – cover, geology, geomorphology, rainfall, slope factor, and contour. Das et al., 2018 showed that remote – sensing and geographical – information – system (RS-GIS) has become a key tool for modelling and thereby mapping of ground-water resources. Subsequently an attempt was made to outline GWP zone within Purulia district West Bengal. They also used analytical hierarchy process (AHP). The GWP maps had been prepared with the help of ArcGIS. The entire district had been classified based on GWP such as high, moderate, low.

Maity et al., 2018a observed that due to over amount of overdraft of groundwater; sea water intrusion was taking place in Purba Medinipur district. On the experimental studies they monitored high values of groundwater quality parameters at various spaces of the district. They also recommended remedial measures to mitigate the problem of seawater intrusion. Maity et al., 2018b also observed that since seawater intrusion was taking place in Purba Medinipur, so that groundwater was taking the shape of cone of depression. They suggested some remedial measure in controlling the seawater intrusion.

Arulbalaji et al., 2019 showed that over increasing population had made stress on groundwater. It was also required the GWP and aquifer water to be increased. To delineate GWP of a little tropical river basin situated in west of Western Ghats, India. A total of 12 numbers thematic type layers such as geomorphology, geology, land – use and land – cover, drainage density, lineament density, rainfall, soil type, slope factor, roughness were studied to determine GWP. Topographic – Wetness – Index, Topographic – Position – Index and Curvature were thereafter prepared and simultaneously studied for GWP zone demarcation. Teja and Singh, 2019 showed that due to over population, deforestation – groundwater level was declining in Mangalagiri Mandal of Andhra Pradesh. They tried to identify GWP using GIS and remote sensing. They identified the factors on which GWP depended. Those were geology, slope, soil, drainage density map, land – use and land – cover, and surface – water bodies. They used thematic map to facilitate their research. Chakraborty et al., 2019 simulated groundwater levels using Visual MODFLOW software for several locations in Purba Medinipur for the years 2019 – 2023 depending on measured borewell discharge data for the years 2012 and 2002. The data were well validated. It had been observed that groundwater levels in Purba Medinipur would be declining in faster rate due to overuse of it. So from the literature review, it has been found that several researches are available on GWP all over world.

3. GWP IN COASTAL AREAS OF PURBA MEDINIPUR

Rainfall is not profuse now. Neither the rivers are filled by rainfall nor is the rain water harvesting a good option. The last yearly rainfall in Medinipur is shown in the Fig 2.

Figure 2: Average yearly rainfall (in mm) in Medinipur

Groundwater depends on topography. On that matter analysis can be done. For that purpose a numeric model ParFlow can be utilized. Subsurface flow is first absorbed by vadose layer. Then it adds to groundwater flow. Digital elevation model (DEM) can be utilized for vertical contour. Model output can be validated by comparing large number of groundwater level. Groundwater flux in x and y direction is evaluated by the following formula given in Equations 11-13.

$$f_x = K \sin \theta_x + K (dP/dx) \cos \theta_x \quad (11)$$

$$f_y = K \sin \theta_y + K (dP/dy) \cos \theta_y \quad (12)$$

$$f_{net} = f_x + f_y \quad (13)$$

Pressure gradient and topographic slope can be read out from DEM. Various metrics can also be found out. Based on which nature of groundwater flow can be determined. If discharge to recharge ratio is more than one unit then surface water is contributing to groundwater. If it is less than one unit then surface water is losing to groundwater. Water table ratio can be found out using Equations 14-15.

$$R_{wt} = \Delta h_{wt} p / d \quad (14)$$

$$\Delta h_{wt} p = R_{rr} L_s^2 / m_e K H \quad (15)$$

where, R_{rr} is Recharge rate, L_s is distance between surface-water bodies, m_e is empirical constant which can be either 16 or 8, and H is mean aquifer thickness.

Then combining Equation 15 with Equation 14 the Equation 16 for R_{wt} becomes

$$R_{wt} = R_{rr} L_s^2 / m_e K_c H d \quad (16)$$

If $R_{wt} > 1$ then groundwater mounding technically is greater than such terrain rise. If $R_{wt} < 1$ then potential mounding is less than such terrain rise. Topographic gradient can be found out if sufficient data is available by using Equation 17.

$$\%TG = \frac{|f_t|}{|f_p| + |f_t|} \times 100 \quad (17)$$

where, f_t is the total flux and f_p is the pressure driven flux. If TG value more than 50 % then topography is more important more important than flux as flux driver. So from the analysis it can be found out that by using numerical method and software packages not only GWP but also velocity vector, velocity gradient map and dependency of GWP on topography can be determined.

5. CONCLUSIONS

Work on GWP has been started in different countries including India long dated back. It has been seen that to carry out GWP not only volume of groundwater pre-monsoon and post monsoon period has been found, but also other attributes which are related to groundwater flux used to be found out. But the important GWP determination has not been done on Purba Medinipur. Many places of Purba Medinipur are salinity affected. Due to increasing population, deforestation, increasing irrigation and huge industry demand, lack of surface water makes the groundwater level declining. Few places like Contai, Egra, and Digha are affected by saltwater intrusion. This phenomenon makes the available useful water more complex and lower quantity. So, to manage water resources efficiently it is required to quantify the groundwater flux very efficiently. Proper application of method can help us not only to determine volume of groundwater but also the other aspects on which it depends and how it can be enhanced. Since rainfall in Purba Medinipur in recent years is low. Surface water is highly contaminated by saline water. So, groundwater extraction at Purba Medinipur become more than its recharge. The lithological data confirms that only small portion of evapotranspiration and precipitation can join GWT. So keeping in mind all these, it can be concluded that GWP of saline prone areas in Purba Medinipur is quite low which can be determined numerically and also by numerical modelling.

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