RESEARCH ARTICLE OPEN ACCESS

Analysis of Ground Water Quality ofSmart City Bhubaneswar, Odisha, India

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ABSTRACT-Groundwater is present underneath the Earth's surface in soil poriferous and in the geological fractures.Ground water is used as potable and withdrawn for agricultural irrigation and industrial use by constructing and operating extraction wells. Bhubaneswar, the smart and the capital city gets water supply from nearby rivers by state Public Health Engineering Department(PHED),dug wells and bore wells.Data from Central Ground Water Board (CGWB) have reflected that ground water is fast depleting in the capital city. Major sources of groundwater pollution include municipality solid waste(MSW),industrial and household chemicals,garbage sanitary landfills,excessive inorganic fertilizers and pesticides,tailings and process sewer water from mines, industrial fracking,oil field brine pits,leaking underground oil storage tanks and pipelines, sewage ooze and septic systems.The ground water sample were collected from dug wells and bore wells at different posh localities and outskirts of Bhubaneswar during summer and rainy seasons and were analyzed for different physico-chemical parameters like pH, electrical conductivity(EC),total dissolved solids(TDS), chemical oxygen demand(COD),dissolved oxygen(DO),total hardness(TH), turbidity, sodium, potassium, magnesium, calcium, iron, hydroxide, fluoride, chloride, carbonate, sulphate, phosphate, silicate and nitrate.Analysis revealed that the unfathomable aquifer contain a little higher concentration of iron than that of endurable limit but the dug well water does not show any higher concentration as the dug well water remains in constant contact of atmospheric air which assuage precipitation and oxidation of iron.Data analysis revealed that the ground water is fit for drinking as pert standard prescribed by Indian Standard Drinking water specification IS:10500-2012 and World Health Organisation(WHO). The awareness on ground water development protection and conservation, water safety plan, ground water recharge and roof top rain water harvesting to be made incumbent on each building in Bhubaneswar smart city.

Key Words :aquifer,COD,CGWB,DO,Groundwater.PHED

Date of Submission: 04-11-2019 Date Of Acceptance: 25-11-2019

I. INTRODUCTION

The smart city Bhubaneswar , the capital of Odisha known as "Temple City of India" a centre of educational,economic,heritageand cultural importance of East India is located between $20^{0}12'$N to $20^{0}25'$N latitude and $85^{0}44'$E to $85^{0}55'$E longitude in Khurda district of Odisha.The city has an average altitude of 45 m above sea level.The city is bounded by the Kuakhai River to the east, the Daya River to the south andNandankanan Zoo and the Chandaka Wildlife Sanctuary lie in thenorthern and western parts. Bhubaneswar is topographically divided into western uplands and eastern lowlands, with hillocks in the western and northern parts.The Bureau of Indian Standards(BIS) spot the city under seismic zone III on a scale from I to V. Bhubaneswar has a tropical savanna and bracing climate. The average annual temperature is 27.4 °C and the average annual rainfall is 1505 mm.The mean monthly potential evapo-transpiration varies from 57mm in January to 248mm in May.The decadal growth rate of the city is 30.2 per cent indicating that Bhubaneswar is growing very fast.On account of rapid industrialization and urbanization,the growth in huge building, apartments, shopingmalls,hospitals, technical institution,touristimportance,a major center for IT and transportation leads to increase in requirement of water for domestic as well as drinking.The water supply is insufficient for the total population for which most of the human population depends on ground water.The groundwater level at each monitoring site is generally influenced by certain parameters, e.g. rainfall, aquifer properties, geomorphology, topographic elevation and slope, land use/land cover, proximity to surface water body, proximity to drainage lines.Ground geology and topography are the principal dominant factors controlling groundwater flow.The greater part of the soluble constituents in ground water and aquifer comes from soluble minerals in soils and sedimentary rocks.The significant sources of contamination in groundwater are unscientifically disposed MSW, farming chemicals, septic waste, landfills, uncontrolled hazardous waste, storage tanks and atmospheric pollutants and cause to become unsafe and unfit for human use.Motality of water and dispersion within the aquifer propagate the pollutant over a wider area. By aquifer storage and recovery (ASR) system, groundwater recharge is augmenting and, recovering the water in the future for agricultural,domestic and potable uses. Our approach in this paper will help in evaluating the chemistry of water quality in order to know the level of pollution, so that remedial measures could be taken to overcome the ground water contamination and make ground water pollution free.

Surface Water :Bhubaneswar city gets water system from Mahanadi, Kuakhai and Daya watercourse. River Dayaand riverKuakhai is needed for drinking water supplies for the current and the future needs of the city and for carrying storm water and the treated sewage from the City. Presently, water provided to the city is regarding 182 MLD. Bhubaneswar is that the temple town and has wells and ponds close to be used throughout daily rituals and gala occasions. There are around 10 heritage tanks & another extra 13manmade tanks covering a district of over 70.39 hectares. Additionally, city is half of canal command space of Puri main canal. Some of the distributaries, minor & sub-minors of this canal passes through the jap fringe of town, wherever it's extensively utilised for agricultural functions. There are some minor cold water springs within the western upland areas. The springs are principally seasonal and discharges of water in these springs are either that water trickles down or oozes out. Discharge begins throughout rainy season and last maximum upto December / January month. The discharges are terribly low -negligible to a most of 20 lpm throughout rainy season and the discharge additionally bit by bit decreases once the stop of season.

Ground Water : Ground water development is through open / dug wells, shallow and deep bore wells as well as shallow & filter purpose tube wells. PHED, Govt of Odishais the major organization for withdrawal of ground water for domestic water provide. Besides this, the domicile complexes like flats and individual homeowners additionally use ground water wherever PHED pipe facility is not offered. The prime weatherworn zone superimposed the gritty and partly lateritizedAthagarh sandstones of Gondwana are chiefly tapped by dug wells & filter purpose tube wells. The bottom water from each the shallow and deeper zones are slightly acidic in nature(pH<7). The deeper aquifer normally contain a touch higher concentration of iron than that of permissible limit however the dug well water ordinarily doesn't show any higher concentration on the far side permissible limit except in isolated cases as dug well water remains in constant contact of region air that facilitates oxidization and precipitation of iron.The depth of the water level ranges from 5-12m within the laterictic and weatherworn sandstones,40-50 m within the broken and friables sand stones forming the deeper aquifers.Storavity describes the property of aquifer to store water.Ground water is going to be depleted in the city and to revive water bodies,space to be given to recharge ground water instead of covering the surface with concrete.

II. MATERIALS AND METHODS

2.1:Study Area:
Ground water samples were collected from the bore wells at ten locations in different areas Bhubaneswar city and outskirts in summer and rainy seasons.

Table-1:Location of sampling points of ground water in Bhubaneswar city and outskirts.

Location No.	Location of sampling point
L1	Saheed Nagar
L2	Chandrasekhar Pur
L3	VaniVihar
L4	Nayapalli
L5	Khandagiri
L6	KalingaVihar
L7	Rasulgarh
L8	Mancheswar
L9	Dhauli
L10	Sundarpada

2.2:Sample Collection and Water Analysis:

The water samples were collected from bore wells at different locations of Bhubaneswar city and outskirts during summer and rainy season in the early hours of the day.Water samples filled in one litre pre-cleaned polythene bottles as per standard procedures.Different physical-chemical-biological parameters were analyzed in the GIET University, Gunupur, Odisha and UtkalUniversity,Vanivihar, Bhubaneswar, Odishalaboratories as per the following standard procedures recommended by BIS 10500-2012 and WHO2004.

Table-2:Methods of analysis of different parameters

PARAMETERS	UNIT	METHOD OF ANALYSIS
pH		pH meter
EC	µS/cm	Conductivity meter
TDS	mg/l	Gavimetric method
COD	ppm	COD method
DO	ppm	Electrode method
TH	mg/l	EDTA Titrimetric method
Turbidity	NTU	Nephelo turbidity
Na^+	mg/l	Flamephotometry
K^+	mg/l	Flamephotometry
Mg^{2+}	mg/l	EDTA Titration
Ca^{2+}	mg/l	EDTA Titration
Iron	mg/l	Spectrophotometer
Alkalinity	mg/l	Titration with H_2SO_4
F^-	mg/l	SPADNS method
Cl^-	mg/l	Argentometric titration
CO_3^{2-}	mg/l	Titration with H_2SO_4
SO_4^{2-}	mg/l	Nepheloturbidimetric method
PO_4^{3-}	mg/l	Spectrophotometer
Silicate	mg/l	Ion exchange method
NO_3^-	mg/l	UV spectrophotometric Screening

2.3:Statistical Analysis:

The results obtained were subjected to two way ANOVA using MS Excel data analysis tool.

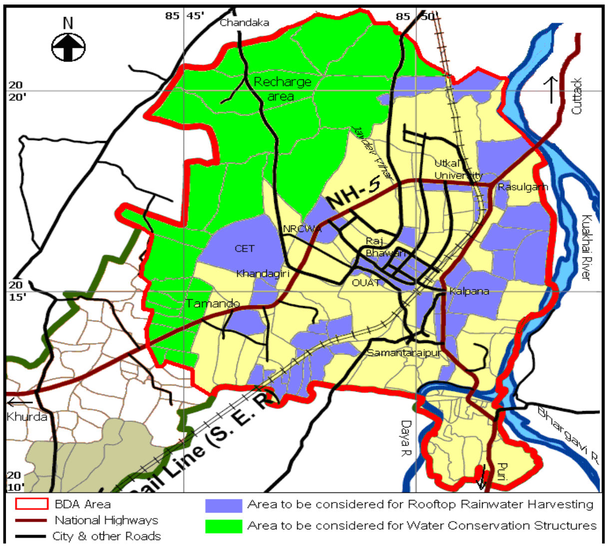

Fig-1:Proposed Rainwater Harvesting Plan for Bhubaneswar City, Odisha

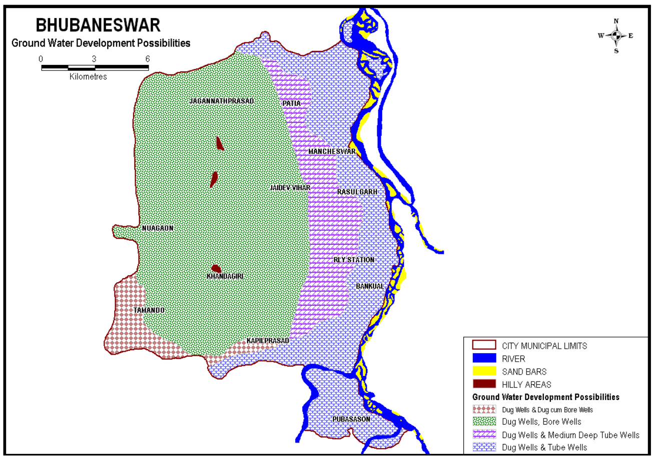

Fig-2:Ground Water Development Possibility Map of Bhubaneswar City, Odisha

Fig-3:BIS report on Tap water quality released in November 2019

III. RESULTAND DISCUSSION

TABLE-3:Physico-chemical parameters of different bore wells in Summer season

PARAMETER	LOCATION OF SAMPLING POINT									
	L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**L10**
pH	7.4	7.6	7.3	7.2	7.4	7.6	6.8	6.7	7.2	7.3
EC	398	578	496	668	688	670	540	690	635	778
TDS	412	408	534	592	578	603	665	634	451	513
COD	6.4	5.6	5.3	4.2	4.6	2.8	5.8	6.2	4.3	5.8
DO	4.7	4.6	4.8	4.2	4.5	4.1	5.7	5.6	4.7	4.8
TH	56	58	54	82	49	58	57	55	61	83
Turbidity	4.1	4.2	4.5	4.2	4.4	3.6	4.6	4.3	6.6	6.8
Na^+	11.8	16.4	13.2	17.2	14.3	16.5	16.8	15.2	13.6	16.4
K^+	14.9	15.8	15.4	16.8	15.5	14.2	14.6	16.8	13.9	16.6
Mg^{2+}	6.8	7.9	6.5	17.8	8.5	6.3	12.4	6.8	11.9	9.4
Ca^{2+}	40.8	79.6	38.3	49.5	48.2	18.6	27.8	36.5	44.3	71.9
Iron	0.31	0.19	0.18	0.29	0.67	0.21	0.15	0.22	0.78	1.28
Alkalinity	169	188	239	335	281	259	145	298	174	198
F^-	0.75	0.71	0.62	0.78	0.73	0.58	0.89	0.13	0.42	0.52
Cl^-	139	248	238	174	186	205	221	223	246	219
CO_3^{2-}	66	72	110	141	88	126	74	98	48	131
SO_4^{2-}	78	83	104	98	72	78	83	112	120	74
PO_4^{3-}	0.03	0.04	0.04	0.06	0.05	0.07	0.08	0.08	0.06	0.05
Silicate	3	14	7	2	4	8	18	7	8	12
NO_3^-	5.9	7.3	5.4	7.2	6.1	3.8	8.5	5.6	3.3	7.6

TABLE-4:Physico-chemical parameters of different bore wells in Rainy season

PARAMETER	LOCATION OF SAMPLING POINT									
	L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**L10**
pH	7.5	7.6	7.5	7.4	7.6	7.8	6.9	6.8	7.4	7.5
EC	416	657	572	746	768	755	628	730	715	845
TDS	378	334	445	530	466	571	618	588	385	496
COD	6.8	5.4	6.4	3.8	3.2	3.6	6.7	5.5	3.4	6.6
DO	4.3	4.2	4.4	4.3	4.1	4.2	5.6	5.3	4.2	5.8
TH	53	57	51	83	45	63	54	48	55	78
Turbidity	4.3	4.4	4.7	3.9	4.3	3.3	4.8	4.5	8.6	7.3
Na^+	13.2	17.8	14.6	18.4	15.3	17.6	17.2	15.4	13.8	16.7
K^+	15.3	16.4	15.8	17.2	15.7	16.3	16.8	17.3	14.4	17.6
Mg^{2+}	7.3	8.4	6.8	18.2	9.3	6.7	13.8	7.8	12.6	10.8
Ca^{2+}	43.4	81.7	39.8	51.5	48.6	19.7	28.9	37.6	44.8	74.8
Iron	0.33	0.24	0.19	0.33	0.72	0.23	0.18	0.25	0.83	1.35
Alkalinity	178	195	245	340	284	268	183	315	192	205
F^-	0.89	0.74	0.67	0.83	0.77	0.63	0.94	0.23	0.47	0.59
Cl^-	128	236	229	136	148	167	199	205	236	209
CO_3^{2-}	69	73	115	143	92	129	87	109	52	135
SO_4^{2-}	87	92	114	106	82	93	95	118	123	94
PO_4^{3-}	0.04	0.06	0.03	0.07	0.04	0.08	0.09	0.07	0.06	0.06
Silicate	4	16	8	3	5	9	20	8	15	13
NO_3^-	7.3	8.4	6.8	7.3	6.2	4.3	9.3	5.7	3.5	8.5

pH LEVEL: pHof ground water at all study sites showed a narrow range of variation 6.7 - 7.8 and well within the permissible limit. At location L8,the water was found acidic as compared to other locations and may be due to industrial discharges and sampling sources close to sewage channel. pH of water in summer season was less than 7 in some locations compare to rainy and may be due to decrease of water level in summer.

ELECTRICAL CONDUCTIVITY: ECis a basic index to judge the suitability of water for drinking and irrigation. Greater the concentration of total dissolved solids in the water , greater the conductivity. Conductivity of water is dependent upon the ions concentration, valence, temperature and ionic mobility of the mineral content in water. Higher EC value may be due to sewage contamination. The conductivity of ground water of study area ranged between 398 µS/cm to 845 µS/cm and the values were within the acceptable limit of drinking water by WHO : 400-2000 µS/cm.

TOTAL DISSOLVED SOLID: TDS value is an imperative and convenient method to indicate the nature of water. Rising of TDS content causes pollution. According to the BIS 10500 standards, the maximum desirable TDS is 500 mg/l and maximum permissible is 2000mg/l. Maximum TDS was observed at sample location L7 is 665mg/l in summer and minimum was observed at sample location L2 is 334mg/l in rainy season. Sample drawn from L6, L7 and L8 recorded higher value of TDS and may be due to domestic sewage. The sample in summer seasons exhibit maximum concentration of TDS compared to rainy season.

CHEMICAL OXYGEN DEMAND : COD is a measure of the oxygen required for the chemical oxidation of soluble and particulate organic matter in water with the help of strong chemical oxidant. A COD test can be used to easily quantitate the amount of organics in water. The COD is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. COD values of all water sample were within the permissible limit of drinking water.

DISSOLVED OXYGEN : DO mensurate the quantityof O_2 dissolved in water. Oxygen from the atmosphere is introduced into the surface water and ground water by slow diffusion. Dissolved oxygen is a key determinant of oxidation-reduction state of water in which compounds are dissolved if O_2 is absent, then redox is low and electrons are plentiful because O_2 does not react with them. DO values less than 4mg/l indicate water pollution. The DO values of water samples at all study locations ranged from 4.1mg/l to 5.8mg/l The values were nearth limits of drinking water standards.

TOTAL HARDNESS: The hardness of ground water results from the presence of divalent metallic cations of which calcium and magnesium are the most abundant.The degree of hardness of drinking water has been classified in terms of the calcium carbonate concentration as follows : Soft 0-60mg/l, medium-60-120mg/l,Hard-120-180mg/l and very hard- >180mg/l. Hard water treatment is done by softener ion exchanger(IE) and reverse osmosis(RO) process.Total hardness in water samples ranged from 45mg/l to 83mg/l. High value of hardness observed in the ground water of study area seemed to have been influenced by their proximity to the sewage drains and nature accumulation of salt from contact with soil. The TH value of water samples taken from all the bore wells were quite less than the levels specified for drinking.

TURBIDITY: Turbidity of drinking water should not be > 5 NTU and should ideally be < 1NTU by WHO. Turbidity in water samples except L9 and L10 were within the permissible limits of IS:10500-2012.Maximum turbidity was observed at sample location L8 is 8.6 NTU in rainy season and minimum was observed at sample location L6 is 3.3NTU. High turbidity of ground water may be due to impact of suspended particles, underground soil and rock**.**

SODIUM: The World Health Organization has established a drinking water guideline of 200 mg of sodium/l on the basis of esthetic considerations. High amound of sodium in drinking water may cause nausea,muscular twitching and convulsions.Sodium content in ground water in all samples in summer and rainy seasons were within the limit.

POTASSIUM: Potassium is an indispensable mineral and electrolyte which involved in muscle contraction, heart function and water balance. A balanced intake of potassium may help reduce hypertension, salt sensitivity and the risk of heart stroke. The potassium content of water samples varies from 13.9 mg/l to17.6 mg/l and best fit within the limit.

MAGNESSIUM: The magnesium values seems to be highest in rainy season at sample location L4 is 18.2mg/l and minimum at L6 is 6.3mg/l in summer. High value of magnesium content in water may cause laxative and lethargy.Higher value may be due to domestic waste and medical waste mixed in water.

CALCIUM: Higher amount of calcium is found at sample location L2 and may be due to geological material aquifers which is composed of calcium mixed with ground water. As per IS:10500-2012 desirable limit for calcium is 75mg/l and 200mg/l in permissible limit.

IRON: Rainwater and drain water infiltrates the soil and underlying geologic formations dissolves iron, causing seepage into aquifers that serve as sources of groundwater for bore wells. Department of Natural Resources (DNR) rules recommend that iron is considered an "aesthetic" or secondary contaminant. Higher value recorded in summer due to decrease of water levels. Iron in ground water is a common problem while WHO recommended level is < 0.3mg/l based on taste and appearance rather than on any detrimental health effect. Iron concentration during our study locations ranged between 0.18mg/l -1.35gm/l. Higher value of iron content in ground water at study location L5,L9 and L10 may be due to dissolution of ferrous borehole, hand-pump components, organic waste plant debris in soil leaching from top soil to the ground water.

ALKALINITY: High alkalinity is essential in our drinking water. The amount of alkalinity must be 20-200 mg/l for typical drinking water. The alkalinity value seems to be highest in rainy season at sampling location L4 is 340 mg/l and minimum at L7 is 145 mg/l in summer season. As per IS:10500-2012 the acceptable limit for alkalinity is 200mg/l and 600mg/l in permissible limit.The high value of alkalinity in the study location is due to increase in action of carbonate as basic material in the soil. Lime stone bedrock and thick deposits of glacial til are good sources of carbonate buffering.

FLUORIDE: All the samples in our study locations were ranged as 0.13mg/l - 0.94mg/l and below permissible limits set by IS:10500-2012 desirable limit for fluoride is 1 and 1.5mg/l in permissible limit. A little increase in fluoride concentration was observed at few locations in all seasons which may be attributed to the geological deposition and geochemistry of the location.High concentration of fluoride in drinking water may cause fluorosis and skeletal problem.

CHLORIDE: Maximum chloride was observed at sample location L2 is 248mg/l in summer season and minimum at L1 is 128mg/l in rainy season. High amount of chloride in ground water may be due to precipitation, animal feeds, use of inorganic fertilizer, chloride stones and leaching process of the soil. The chloride level for Public drinking water standards requires not to exceed 250mg/l. As per IS:10500-2012 desirable limit for chloride is 250 and 1000mg/l in permissible limit.

CARBONATE : Bicarbonate and carbonate ions in water can remove toxic metals, such as lead and cadmium, by precipitating the metals out of solution. A significant contribution from CO_3^{2-} and other anions, emerges only at pH levels greater than approximately 9.0.Water containing calcium carbonate at concentration below 60mg/l is generally considered as soft and 60-120mg/l moderately hard. The maximum carbonate concentration was found in study location L10 is 135mg/l in rainy season and minimum at L9 is 48gm/l in summer season and the ranges were within the permissible limit.

SULPHATE : Sulfate is one of the major dissolved components of rain. High concentrations of sulphate in the water we drink can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. Many sulphate ions are produced by oxidation of their ores, MSW and also in industrial wastes. Sulphate is classified under the secondary maximum contaminant level(SMCL) standards and for drinking water is 250mg/l. The desirable limit is 200 mg/l and permissible limit is 400 mg/l in as per IS:10500-2012 The sulphate concentration in all our study locations ranged from 72mg/l - 120mg/l and below the permissible limit.High concentration of sulphate in drinking water may cause diarrhea and dehydration.

PHOSPHATE: Ground water contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soil to retain phosphate.There is no BIS standard permissible limit for phosphate for drinking water, while WHO 2004 has fixed it to be 0.1 mg/l. Phosphate concentration in our ten study locations were within the permissible limits.

SILICATE: The silica content in natural water is commonly in the 5 to 25 mg/l range, although concentrations over 100 mg/l occur in some areas as reviewed. Silicates in water is highly beneficial, cause water quality and treatment problems. Silicate concentration in our 10 study locations in both summer and rainy seasons ranged between 2mg/l to 20 mg/l and lies within the permissible limit.

NITRATE: Nitrate is the most common groundwater contaminant. Nitrate in groundwater originates primarily from chemical and fertilizer factories, matter of animals, decline vegetables, domestic and industrial waste discharge, septic systems and manure storage or spreading operations. The maximum nitrate was observed at study location L7 is 9.3mg/l in rainy season and minimum at L9 is 3.3mg/l. The nitrate range in all sampling locations were within the desirable limit 45 mg/l as per IS10500-2012 and no relaxation in permissible limit.High concentration of nitrate in drinking water may cause "blue baby" disease.

IV. CONCLUSION

From the above study, the concluded investigation of ground water quality of Bhubaneswar city and outskirts with respect to physical-chemical-biological parameters that the water is safe for consumption as pert safe limits prescribed by WHO and IS 10500-2012.Our analysis data were agreed with BIS data released in English daily Times of India as “BIS:Mumbai’s tap water best,Bhubaneswar’s a close second” in November 2019.The ground water of our ten study locations was also safe as none of the locations in summer and winter season were above WHO limit for total coliform(TC) and fecal coli form(FC). Result of water quality assessment showed that most of water quality parameters slightly higher in the rainy season than the summer season. Some locations show deeper water level condition during summer season due to topographic condition and water table gradient. Adopting artificial recharge techniques and rain water harvesting methods help the quality of ground water. Awareness about monitoring of ground water quality protection and conservation must be initiated. Ground water need to be protected from future contamination of aquifer and improved by advocating disposal strategies, septic systems, federal quality standards, control of diffuse pollution and consideration to preferential flow and solute transport**.** Periodic estimation of ground water quality is highly necessary in order to ascertain the quality of water to be used for drinking and domestic purposes as a large population of Bhubaneswar and outskirts depends on.

V. ACKNOWLEDGEMENTS

The authors are highly thankful to Mr. Biranchi Narayan Panda,President Jupiter Group of Institutions,Bhubaneswar,Odisha for his continuous moral support and encouragement to carry out the research work.

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Bharat Chandra Kalapahad "Analysis of Ground Water Quality of Smart City Bhubaneswar, Odisha, India" International Journal of Engineering Research and Applications (IJERA), vol. 9, no. 11, 2019, pp48-54