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Hydrogeochemical Characterization and Numerical Flow Modeling of the Ujjain Aquifer System

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Abstract: ***Water – water - water its one of the most precious Compound present on Earth. Without water life is not possible in any means. The history depicts that human beings are also water born, that's why we our self own 70% of water in our body. On earth we have tremendous amount of water available but not for drinking. Generally for drinking water we have limited ourselves in either fresh surface water or ground water. The ground water has its own place in our daily life no matter it's from a dug well or bore well. In Ujjain city we have about 33, 390 dug wells and about 47, 755 bore wells/ tube wells, these are large numbers comparing to a B class city but still their misuse happens and the city is thirsty and we look in hope for the Public Health Engineering (P. H. E.) department to supply 11M. L. D. (Million Liters per Day) water to fulfill the needs of city. In this research we have selected 7 different bore wells across the city area and analyzed their Physico chemical parameters for drinking water. General overview of our result is that the water of these bore wells is very good for drinking and the parameters value are well within the limits. We in this research also propose a ground water model to predict the hydrological changes of the local area and also give the mathematical equations and solutions for this model. Application of this model will increase the ground level of water. This will lead to the abundance of drinking water will be available to local people of Ujjain.***

Keywords: Water, Precious, Compound, History, Fresh Surface Water, Dug Well, Bore Well, Tube Well, Ujjain city, Public Health Engineering Department, Million Liters per Day, Gambhir Dam

1. Introduction

An unambiguous definition of a ground water model cannot be given but we can say it is a scaled model of an aquifer; they are made to predict different hydrological effects on ground water and nearby areas. For the mathematical modeling we need the hydrological inputs of data of hydraulic parameters. These parameter inputs are physical and chemical quantities of aquifer and can vary time to time and place to place. Some parameters are been influenced by various geological activities and alerts in water table takes place and this is known as subsidence.

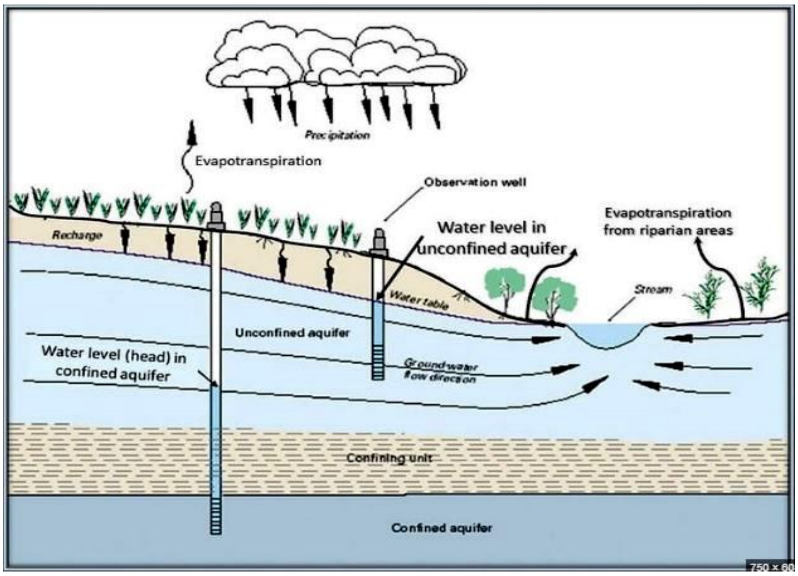

Figure 1: Flow of water on Earth

The application of ground water model depends upon various situations and accuracy of the data still in the actual system there will be some natural parameters giving us typical change in concentrations, these can be **Errors**. Determination of these parameters needs consistency, considerable study, pre and post pumping tests. So, the models we generally use give us the *"If - Then"* analysis with different influences and errors. These analyses are able to produce a rough estimation of ground water behavior and so the sensitivity analysis is needed to find out that which parameter influences the verity of ground water and emphasis on investigation of which parameter gives more influences to the influence factors. Various old data methods have missing information's so we need a sufficient data for calibration and so the model is made and then calibrated, than we found certain parameters to take care of and then implemented again.

The Model – The ground water model can be one dimensional, two dimensional, or three dimensional in nature. These three dimensional model can be divided into two parts i. e. the semi three dimensional model and truly three dimensional model. In the breakages we see that one dimensional model can be used for vertical flow in the system of parallel horizontal layer system. The two dimensional model are applied to vertical plane models in parallel vertical system, the basic example of two dimensional model is the spacing equation of a sub surface drain system.

The three dimensional model requires disintegration of equal flow of domain for vertical and horizontal sense so we have to calculate ground water flow equations. The semi three dimensional model have grid over the two dimensional network of polygons, rectangles, triangles etc. So that the flow domain is sub - divided in vertical prisms, by this we can understand the three dimensional models with horizontal and vertical sub - surface drainage systems.

Flow Equation of the Ground water Movement: It is the mathematical calculation of the flow of ground water through an aquifer, the diffusion equation gives us the transit flow of ground water similarly, the heat conduction or transfer describe the flow of heat and the steady state is been described by **Laplace equation**. This Laplace equation is a form of potential flow and has various analogs in different fields. The mass balance of the flowing water should be done, this flux of relationship is been given a constitutive equation called **Darcy's Law**.

The mass balance should be along side of Darcy's Law and this balance should be used in heat transfer as we all know that mass cannot be destroyed, so the conservation of mass in time difference (Δt) is the change of storage.

Transient flow Movement – It is also known as the diffusion equation represented by density and time. The mass flux around the boundaries, so the incompressible liquid becomes volume flux, using Taylor series method we represent this flux. This differential calculus is taken, calculated giving us the final form of ground water flow. For various materials present in ground water we apply the potential flow method for mixed /unmixed confirmed/un - confirmed cases.

Groundwater Energy Balance – This is the incoming hydraulic energy balance which is been associated with ground water. This energy conversion is into the body or the outflow energy into heat, results the change of status of the ground water level. While flowing, the groundwater looses a large amount of energy due to friction of the flow so this friction converts the hydraulic energy in heat of the unconfined aquifer.

In mathematical terms the mass - energy balance can be obtained by differentiation in cross section of integral of iron in the direction of the follow of ground water using the **Leibniz** rule. In this rule if the change in direction of flow is been taken into account than its simplified using **Dupuit** assumption of water. The friction losses in the flow is been given in the **Joule's** law of friction.

To calculate shape and size of water table in a specific aquifer the model we have above is very helpful to us and the equations must be solved by integrations i. e. the trial and error methods. The initial assumptions if made should be analyzed again and the errors must be fixed as soon as possible. The level of water table at a point should not alter from the assumed level else the model will fail.

2. Results and Discussions

Many water quality parameters are taken for drinking water we have taken 24 of the parameters for ground water drinking water of the 7 different bore wells across the city area.

S. No.	Parameters	Units	Jansapura	Mullapura	Kartik - Chauk	Begum Ka Bag	Mahashweta Nagar	Ujjain Engineering Collage, Ujjain	Vikram University campus
			1	2	3	4	5	6	7
1	Temperature	°c	27.3	29.6	28.4	27.8	28.6	29.5	27.8
2	Turbidity	NTU	59.4	56.3	55.6	57	52.6	63.5	68.9
3	Colour	Pt. CoScale	1						
4	Odor		Odorless						
5	pH		8.32	7.89	8.21	7.94	8.25	8.12	8.35
6	Specific Conductivity	Ω	1049	1516	1415	1269	1152	1160	1255
7	Total Solids	Mg/L	775	996	964	920	950	825	830
8	Suspended Solids	Mg/L	38	32	52	54	59	56	62
9	Dissolved Solids	Mg/L	737	963	912	866	891	769	789
10	Ammonium Nitrogen	Mg/L	0.0588	0.985	0.962	0.925	1.021	1.102	1.15
11	Nitrite Nitrogen	Mg/L	0.0156	0.006	0.0096	0.195	0.184	0.165	0.175
12	Nitrate Nitrogen	Mg/L	2.68	3.56	3.54	3.25	3.87	4.05	4.23
13	Phosphate	Mg/L	0.105	0.064	0.056	0.07	0.058	0.068	0.08
14	Chloride	Mg/L	159	168	187	185	190	196	175
15	Total Alkalinity	Mg/L	333	238.4	264.8	257.6	300.5	298.6	233.5
16	Total Hardness	Mg/L	362	350	325	330	365	320	300
17	Calcium Hardness	Mg/L	135	127	130	120	125	126	120
18	Magnesium Hardness	Mg/L	211	191.2	198	196.5	195.3	156.7	150.2
19	Sulphate	Mg/L	75.6	84.6	90.5	95.5	90.2	93.5	95.5
20	D. O.	Mg/L	6.04	6.65	7.05	7	6.56	6.75	7.15
21	B. O. D.	Mg/L	10.5	13.5	16.5	18.5	20	30	35

22	C. O. D.	Mg/L	60	65	70	70	60	55	55
23	Sodium	Mg/L	9.5	12.8	13.5	12.5	11.5	14	12.7
24	Potassium	Mg/L	20	25	20	20	22	24	20

3. Conclusion

In Ujjain city we have about 33, 390 dug wells and about 47, 755 bore wells/ tube wells, these are large numbers comparing to a B class city but still their misuse happens and the city is thirsty and we look in hope for the Public Health Engineering (P. H. E.) department to supply 11M. L. D. (Million Liters per Day) water to fulfill the needs of city the three dimensional model system we have taken is one of the best in the business. This model also looks for various equations given from time to time by Joule, Laplace, Darcy, Leibniz and Dupuit; we also have taken various aspects like transient flow, flow energy loss, friction loss and mathematical calculations for errors. So the model becomes strong and will sustain in future too.

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