Groundwater Demarcation of Seri Distributary Command Area

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Abstract: **This study is a part of a research work which is to be completed under the project "Sustainable fresh groundwater management for irrigated Agriculture in lower Indus basin (LIB) using PMWIN Model" funded by HEC under NRPU program. The project research emphases on managing the sustainability of groundwater and provides livelihoods to the irrigated agricultural community in the lower part of Sindh. Under this research work 03 districts namely; Tando Alhyar, Tando Muhammad Khan and Hyderabad have been chosen. This paper aims to identify the groundwater quantum and quality under the boundary of Seri distributary command area, which is off-taking from right side of Rohri canal at Almani X-regulator (RD-1038). The GPS coordinates at its head regulator are 25° 14' 41.97" N and 68° 29' 50.01" E. It lies in administrative boundary of district Hyderabad, Sindh, Pakistan. In this study different activities (field experimentation and computer analysis) have been carried out. Under this study, the groundwater (GW) quality and aquifer potential has been assessed. Groundwater is generated in weathered layers and semi-weathered layers / crushed layers of hard rock areas with a thickness of 5 to 20 m [1]. Groundwater is used as a supplement for drinking, irrigation and industrial sectors. Due to the lack of surface water, groundwater is the second most common option to supplement canal water to meet the water needs of various water-consuming sectors. The groundwater quantum and quality was determined through electrical resistivity survey (ERS). Through Geo-electrical resistivity survey, the underground resistance of the study area at different selected points was determined using Terrameter SAS 4000.The Vertical Electric Soundings (VES) were done at each node point of (2km x 2km each cell dimension) grid, up to shallow depth of 150 meters below ground surface The collected data was further analyzed using IX1D software to quality wise quantum of groundwater in different geological layers. Finally, the demarcation map of the results was prepared for each layer using ArcGIS. In layers WT to 25m, 50-75m, 75-100m, and 100-150m from WT, the maximum amount was found in freshwater. In the second layer (25-50m), the maximum amount of GW was marginal fresh. On the other hand, saline waterwas found in the lowest amount in all layers (ie average <7%). The study recommended that the tubewells be installed at a shallower depth to avoid salt water upconing problem, because the fresh aquifers overlie highly saline aquifer. It is also suggested that the artificial recharging must be done by constructing open wells in the suitable depressed places to make water balance.**

***Keywords*: ERS, ArcGIS, Groundwater, IX1D software, Seri distributary, Terrameter SAS 4000,**

I. INTRODUCTION

Groundwater investigations are becoming progressively imperative worldwide as demand for irrigation water continues to increase. Pakistan lies in arid to semi-arid climate zones and relies heavily on irrigation through a well-established irrigation network limited primarily to the Indus Basin. As an outcome of scarce water availability, country can only irrigate 22 million hectares (M he) land out of total 31 M he accessible. Though, providing more arable land depends on water availability, but water availability has not been regularly distributed over the years. In addition, seasonal fluctuations, droughts and floods can create dangerous conditions. The canal water supply is very partial, fluctuating and unpredictable. In addition, large trucks in irrigation systems face environmental problems such as water harvesting, salinity and salinity. In this condition, the development of groundwater (GW) is the only the freshwater resources to the farmers have made to increase water supply and strengthen irrigation water management. This demonstrates the reputation and role of groundwater to encounter Pakistan's agricultural water demand. Utilizing geophysical strategies to assess and screen geotechnical characteristics makes them non-intrusive, inexpensive to perform, bore many test wells, and perform tasks, it is surprisingly useful for speeding up. One of the geophysical methods commonly used in building tests is the electrical resistivity strategy [1].

Schlumberger VES helps you discover the depths of sandy aquifers in Myanmar's deep sea 10 to 13 meters, 30 to 40 meters thick. In addition, VES can be very helpful in determining aquifer risk assessments [2]. The most common methods are ER and EM used as part of hydro geological applications, which take into account the physical properties and electrical conductivity of aquifer [3].

As already mentioned, learning neighboring terrain, field recognition, and archiving from current wells is necessary to effectively place useful boreholes. Similarly, using an integrated geophysical approach to investigate massive gravitational mass development, the results are advantageous to confirm the progress of oscillating mass development in a time-lapse geophysical review. The utilization of VES strategy in searching for GW and the calculation of water-powered qualities, for example, pressure driven conductivity and transmissivity, from deciphered geophysical information has turned out to be exceptionally viable and effective [4].

A study was conducted to compute the potential for groundwater vulnerability using geo-electric technique. This study was carried out near dairy farm at Khizarabad of Sargodha district. Total of 8VES were done at this site on node points of 5km x 5km grid. The results considered into 3 layers i.e. high resistivity (from 10 to 20 ohm-m), saturated alluvium with low resistivity (less than 20 ohm-m) and dry alluvium. The study found unconfined aquifer containing agricultural pollutants in the study area [5].

Mukherjee et al [6] conduct research in the arid Kachchh region, district of Gujarat and reported GW potential zone. The thematic layers were generated by means of ancillary data and digital satellite image. The potential regions were attained by weighted overlay analysis, the status specified for separately specific parameter of each thematic map and weights were allotted as per their effect.

This paper presents the resistivity survey results of GW potential and its quality in the Seri distribution command area of Hyderabad, Sindh Pakistan, as determined by electrical resistivity surveys.

II. METHODOLOGY

Study Area

Seri distributary command has been taken as study area. The distributary is off-taking from Rohri canal at Almani X-regulator, RD 1038. It is passing through Tando Fazal Union council of district Hyderabad, Sindh, Pakistan. The GPS co-ordinates of head regulator of the distributary are 25° 14’ 41.97” N and 68° 29’ 50.01” E. Google image of layout plan of Seri distributary and its water-course out-let location points are shown in Fig. 1.

Fig 1: Map of Seri distributary with location points of water-course outlets

Data Collection

The resistivity survey was conducted at node points of 2km x 2km for the usefulness of groundwater mapping. To facilitate the proposed survey points, a 1km x 1km grid was prepared on google earth. The locations of survey points are shown in Fig. 2. Total 12 EVS were performed at the node points on the regular grid for shallow GW investigations up to depth 150 meters using ABEM Terrameter SAS 4000. The Terameter equipment was borrowed from USPACAS-W, MUET Jamshoro and training to the student was received by geo-physical expert, DRIP Tandojam.

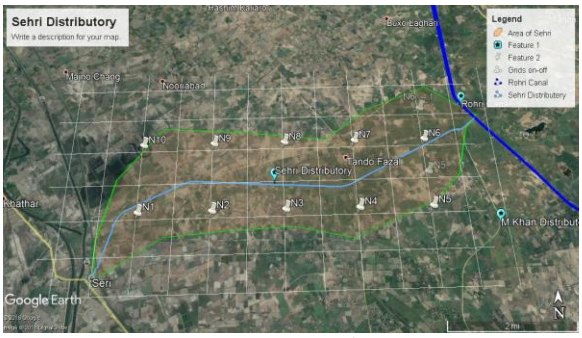


Fig. 2: VES points on 1km x 1km prepared grid for Seri distributary command area

A. ERS Survey

ERS is used for environmental surveys, hydrological surveys, geotechnical surveys, and mining surveys. The purpose of VES survey was to adventure the GW in the survey area. Prior to selecting potential sites for the exploitation, tubewell development and specific GW pumping, it is essential to obtain research information on hydrogeological conditions like: thickness and range of fresh/saline aquifers, nature of the aquifer lithology in the survey area for the estimation of GW quality profile.

B. ERS Data Collection

The Terameter was used in the field to measure current and potential values. In Schlumberger array’s case, the straight line proportionately of the electrodes planning is done crossing the midpoint. For two outer electrodes A and B used as current electrodes, and the two inner M and N electrodes are used for resulting potential difference across these M and N electrode points.

The distance of potential electrodes from the center is referred to MN/2 and distance of current electrodes is referred to AB/2, which are described the array. MN / 2 is set aside suitably small related to AB/2. (Fig. 3)

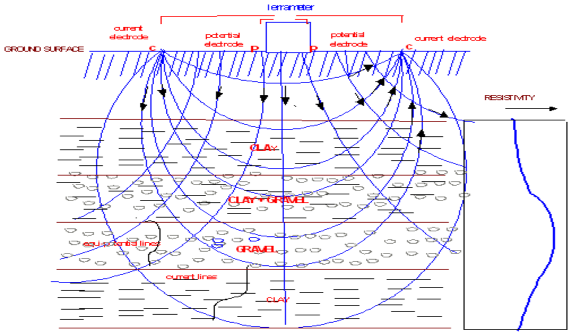


Fig. 3: Arrangement of Current and Potential electrodes

Below the ground surface, high DC voltage and high current is passed through A and B electrodes. A constant current I (mill amperes) passes from A to B electrodes through the ground plane, a potential difference is created at points M and N, and resistance R (milliohms or ohms) is displayed on the Terameter display. Potential electrode leftovers at less distance from the center as compared to distance of current electrodes from the center. To get values of resistivity for deeper layers, the electrodes distance from central point is increased. This procedure has been embraced at all the node points in the study area. The readings were taken up to the depth of 150m down from ground surface. The readings for the resistivity were noted through this process on the Tterrameter display.

C. ERS Data Evaluation Using IX1D Software

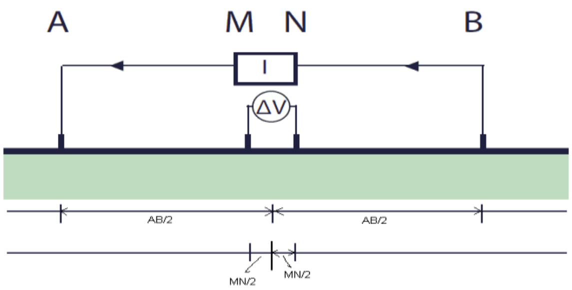
The resistivity field curves are achieved, the plots between apparent resistivity and depth are prepared on log-log paper. Getting plots of curves, the field data was recorded on computer. The interpretation of sounding was completed the using IX1D, software. The layer models calculation is done with iterative method. By iterating individually, adjustments of model parameters and corresponding curve deviations from dignified curves are checked. RMSE is calculated to define the deviation at the end of each iteration. After completing the calculation, the model results with least error is drawn, showing the layer thickness and the corresponding interpreted resistivity. In exercise, the clarification of resistivity exploration is always exposed to equal beliefs. In other words, resistivity exploration can be coordinated with a number of slightly deviating model curves that represent changed GW level resistivity stratification dependent on the local GW performance. Thus, the data interpreters face many choices of a single field curve to select the most reliable model of underground situations.

D. Resistivity Measurement

The resistivity (ρ), dignified in Ω-m, is a bulk property of the material and indicates how much the material suppresses the current. Apparent resistivity (ρa) and R are the Schlumberger electrode resistances are determined by formula given below

$$\rho a = GR \tag{1}$$

Where;
The G is geometric factor, which is computed using following equation [7](Srinivasa, 2004)



$$G = \pi\left[\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2\right] \tag{2}$$

Fig. 4: Plan of a Schlumberger array

E. ERS Data Interpretation

The resistivity measured through the interpretation process resulted in an electrical subsurface layers, these layers need to correlate with the underground geological situations. This alteration of interpreted layers into lithological units is principally centered on the geological evidence gotten various data collected sources in the area such as; tube wells, test holes etc. Different classes of resistivity zones are developed by underground hydrogeological conditions. For explored region, the correlation established between subsurface geological condition and electrical resistivity water content represented in following Table 1.

Table 1: The relationship of resistivity with quality of water content and Geological formation and

Zone of resistivity	Resistivity (Ωm)	Geological formation association of with water content quality
Zone of low resistivity	Less than 10	Zone signifies the availability of soil fine material such as clay / shale with infrequent sand, so there may be saline water to a smaller amount of saline posture potential.
Zone medium resistivity	Between 10 and 30	Zone denotes the availability of medium sand with mixing of some clay. The availability of alternate bedding of clay/shale and sand is also seen.
Zone of high resistivity	Between 30 and 100	This zone is interpreted as the advantage of coarse material, that is, sand and good quality GW.
Zone of very high Resistivity	Above 100	This zone represents the unsaturated zone above the groundwater surface and the occurrence of bedrock below the groundwater surface.

III. RESULTS AND DISCUSSIONS

The demarcation map for GW quality of Seri distributary command area have been developed for 5 different depths viz., from WT to 25m below ground surface (bgs), 25-50m, 50-75m, 75-100m and 100-150m. The standard EC values for different water qualities are recommended as, the water has EC value <1.5 dS/m is termed as fresh water (FW), 1.5 to 2.5 dS/m termed as marginal fresh water (MFW), 2.5-4.0 dS/m marginal saline water (MSW) and EC > 4.0 dS/m is categorized as saline water (SW). The boundary map of different GW qualities for the corresponding layers in the study area were determined and are described/discussed as follows:

III.1 GW quality map from WT to 25 m depth

The GW quality values, estimated by GIS 10.3, and corresponding map for the layer of depth ranging from WT to 25m are presented in Table 2 and Fig.5 respectively. The results presented in Figure 5 show that at depths ranging from WT to 25m, FW is 65%, MFW is 11%, MSW is 17.7% and SW is only 6.3%. From this picture it is found that this depth contains maximum quantum (65%) of fresh GW, whereas a little quantum (6.3%) is of SW.

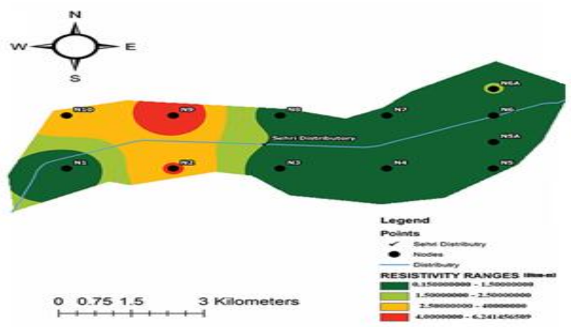


Fig. 5: GW quality at depth from WT to 25m

Table 2: Quality-wise quantum of GW at 25m depth

Sr. No.	Water Quality class	Area on GIS Map	
		Km^2	% age
1	FW	21.56	65
2	MFW	3.63	11
3	MSW	5.87	17.7
4	SW	2.09	6.3
	Total	33.2	100

III.2 GW quality map from 25m to 50m depth

The GW quality values and demarcation map for this depth, ranging from 25m to 50m are presented in Table 3 and Fig.6 respectively. The quality results in this map show that the quantum of FW was found 18%, MFW 54%; MSW 16% and SW water 12%. This zone contains the maximum percentage is of MFW i.e. 54% and minimum percentage is of SW i.e. 12.5%.

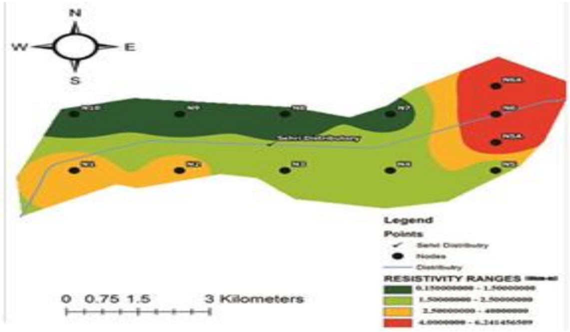


Fig. 6: GW quality at depth from 25 to 50m

Table 3: Quality-wise quantum of GW at depth of 25-50m

Sr. No.	Water Quality class	Area on GIS Map	
		Km2	% age
1	FW	6.142	18.5
2	MFW	17.928	54
3	MSW	5.312	16
4	SW	4.15	12.5
	Total	33.2	100

III.3 GW quality map from 50m to 75m depth

The GW quality values and demarcation map for this depth, ranging from 50m to 75m are presented in Table 4 and Fig.7 respectively. The quality results in this map show that the quantum of FW was found 66.5%, MFW 18%; MSW 8.5% and SW water 7%. This zone contains the maximum percentage of FW i.e. 66.6% and minimum percentage of SW i.e. only7%.

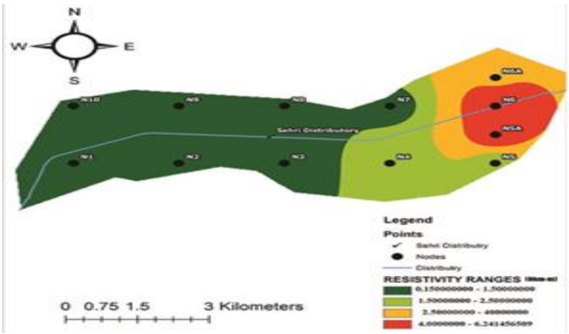


Fig. 7: GW quality at depth from 50 to 75m

Table 4: Quality-wise quantum of GW at depth of 50-75m depth

Sr. No.	Water Quality class	Area on GIS Map	
		Km^2	% age
1	FW	22.07	66.5
2	MFW	5.976	18
3	MSW	2.882	8.5
4	SW	2.272	7
	Total	33.2	100

III.4 GW quality map from 75m to 100m depth

The GW quality values and demarcation map for this depth, ranging from 75m to 100m are presented in Table 5 and Fig.8 respectively. The GW quality results in this map show that the quantum of FW was found 73%, MFW 15%; MSW 8% and SW water 4%. This zone contains the maximum percentage of FW i.e. 73% and minimum percentage of SW i.e. only4%.

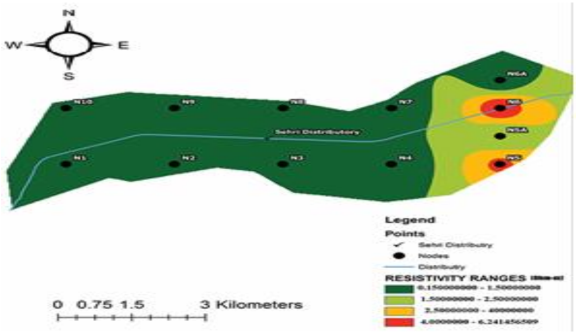


Fig. 8: GW quality at depth from 75 to 100m

Table 5: Quality-wise quantum of GW at depth of 75-100m depth

Sr. No.	Water Quality class	Area on GIS Map	
		Km^2	% age
1	FW	24.236	73
2	MFW	4.98	15
3	MSW	2.656	8
4	SW	1.328	4
	Total	33.2	100

III.5 GW quality map from 100 to 150m depth

The GW quality values and demarcation map for this depth, ranging from 100 to 150m are presented in Table 6 and Fig.9 respectively. The quality results in this map show that the quantum of FW was found 72%, MFW 16%; MSW 8% and SW water 4%. This zone contains the maximum percentage of FW i.e. 72% and minimum percentage of SW i.e. only4%.

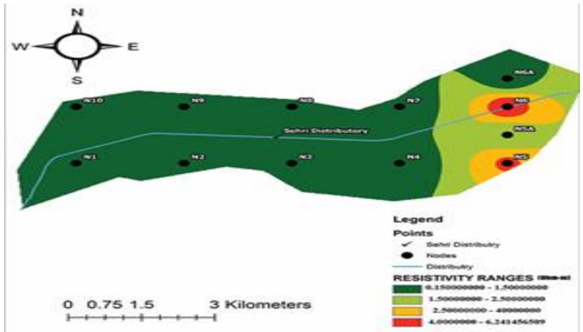


Fig. 9: GW quality at depth from 100 to 150m

Table 6: Quality-wise quantum of GW at depth of 100-150m depth

Sr. No.	Water Quality class	Area on GIS Map	
		Km^2	% age
1	FW	23.904	72
2	MFW	5.312	16
3	MSW	2.656	8
4	SW	1.328	4
	Total	**33.2**	**100**

IV. CONCLUSIONS

From the present study, following conclusions are derived:

- ERS was performed in the command area of the Seri tributary of the Hyderabad district to identify the GW quantum on quality. Depending on the Geo-ERS data analysis, the results shown in Table 2 ranged from WT to a depth of 25m, designate that the overall water quality in the study area up to depth of 25m, the FW was found 65%, MFW 11%; MSW 17.7% and SW 6.3%. This zone contains maximum quantum of FW, 65%.

- The results presented in Table 3 show that the quality-wise quantum of groundwater in the layer of depth ranging from 25 to 50m was found as 18% of FW, 54% of MFW; 16% of MSW and 12.5% of SW. This zone contains maximum quantum of MFW, 54%.
- The results presented in Table 4 indicate that in the layer of depth ranging from 50 to 75m, the quality-wise quantum of GW was found as 66.5% of FW, 18% of MFW; 8.5% of MSW and only 7% of SW. This zone contains maximum quantum of FW, 66.5%.
- The results presented in Table 5 reveal that in the layer of depth ranging from 75 to 100m, the quality-wise quantum of GW was found as 73% of FW, 15% of MFW; 8% of MSW and only 4% of SW. This zone contains maximum quantum of FW i.e. 73%.
- The presented in Table 6 indicate that in the layer of depth ranging from 100 to 150m, the quality-wise quantum of GW was found as 72% of FW, 16% of MFW; 8% of MSW and only 4% of SW. This zone contains maximum quantum of FW, 72%.

V. SUGGESTIONS AND RECOMMENDATIONS

In the study area, the quality of groundwater up to 150 m in depth found marginal-fresh to fresh groundwater. Therefore, wells can be installed in all layers. However, it is recommended to install them at a shallower depth to avoid salt water upconing, because the fresh aquifers overlie highly saline aquifer.

If the amount of pumped water from the aquifer is more than recharge, then the watertable be deplete and the water quality may be deteriorated. Therefore, it is suggested that artificial recharging must also be done by building an open well in a suitable depressed place in this region.

VI. ACKNOWLEDGEMENT

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