Determination of Groundwater Quality through Vertical Electrical Sounding and its Demarcation using ArcGIS-A case study of Tando Allahyar–II Distributary Command Area

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Abstract: **Water requirement is not met in agricultural sector because canal capacity is less than irrigation demand. Groundwater plays a vital role in these circumstances. Fertility of soil is adversely affected because of groundwater is utilized without analysis. The aim of this research is to determine groundwater quantity and quantum by ERS (Electrical Resistivity Survey) at Tando Allahyar distributary- II command area. The terrameter (ABEM Terrameter SAS 4000) was used to gather data by using electrode arrangement with half current electrodes (AB/2) having spacing from 2 meters to 150 meters and potential electrodes (MN) varies between 0.5 meter to 20 meters. VES was held at 18 nodes; with 2 km x 2 km area for shallow groundwater survey till the 150 meters depth. Stats were assessed in terms of resistivity and respective depth of numerous underlying layers using "Interpex IX1D" software. The apparent resistivity varies from 0.11 Ω.meter to 293.99 Ω.meters with depths of 1.36 m and 150 m respectively.**

Keywords: **Groundwater quality, Vertical Electrical Sounding (VES), Tando Allahyar, Resistivity**

I. INTRODUCTION

Groundwater is available in huge quantity. It is used for drinking purposes because it is free from contaminants and it requires little purification to use it for domestic or industrial purposes [1]. It only contributes meager amount of water but huge amount of that water is fresh [2] It is main source of irrigation in South Asia. It is second largest water resource of livelihood to people in rural areas [3]. It's quality in some areas is worse than canal water containing salts. Hence, in such areas ground water may be a serious threat to agricultural lands. [4]. It is believed that groundwater exists in large lakes or pools under the surface of earth [5]. Irrigating land depends on water availability but it is not uniformly divided throughout the year. Moreover, seasonal changes, famine and Inundation can cause devastating situation. Supply of surface water is also unjust, uncomfortable and undependable [6]. Also, underground water quality has reduced hugely. Intrusion of seawater is also posing threats to underground water sources. Scope for pumping of quality underground water in Sindh is limited due to absence of scientific and dependable knowledge on underground water presence [7]. Vertical electrical sounding method is one of the surface geo-electrical surveys used in prospecting for groundwater [8]. To enhance water supply, underground water is lone source of water for farmers. The usage of geo-physical tactics to investigate water quality and plotting of map of underground sources have been increased tremendously in last decade [9]. The VES tactics are used effectively to assess position of groundwater and analyze the underground layer [10]. Water content, porosity of the soil and salt concentration of underground water are factor which affect resistivity [11]. Specifically, the electrical resistivity method is quite simple and very easy to assess data in comparison to other tactics. It is very effective. [12]. Water related resistivity ranges from 0.2 ohm-meter to 100 ohm-meter depends on ion concentration and dissolved solids [13]. The main objective of this research is to determine groundwater quality through Vertical Electrical Sounding (VES) and its demarcation using ArcGIS for the Tando Allahyar-II distributary command area.

II. MATERIAL AND METHOD

Study Area

Tando Allahyar-II distributary of Rohri main canal has been taken as the study area. This distributary is off-taking from Naseer canal at 33 RD. The salient features of the selected distributary are given in Table 1:

Table 1: salient features of Tando Allahyar-II distributary

S.No	Description	Details
1	Name of distributary	Tando Allahyar -II distributary
2	Parent Canal	Naseer Canal
3	Gross Commanded Area (acres)	15400
4	Cultivable Commanded Area (acres)	14464
5	Length of the distributary (RD)	70
6	Design discharge (cfs)	61.83
7	No. of watercourses	33

Electrical Resistivity Survey (ERS) has been carried out in the study area through apparatus "ABEM Terrameter SAS 4000". The resistivity was carried at 2 km x 2km area; and a total of 18 points were surveyed for this purpose. The vertical electrical sounding (VES) was conducted at the selected plain surface/place within command area. The rods were temporarily fixed at ground surface at various distances from 2 m to 150 m away from selected middle (or the central) point to develop electric field through current. The command area and the VES or resistivity points (Nodes) are shown in Figure 1.

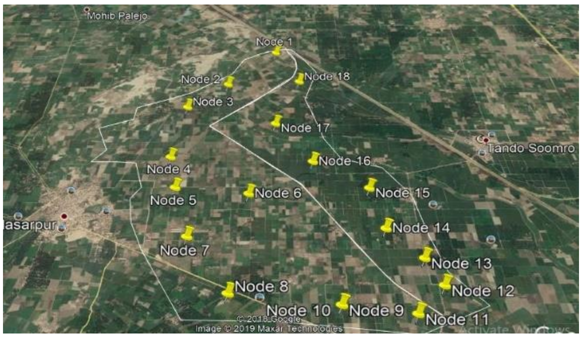

Fig 1: Command area of Tando Allahyar-II distributary with 18 VES Nodes

Instrument-ABEM Terrameter SAS 4000

The Terrameter SAS 4000 shown in following figure 2 was used to carry out electrical resistivity survey for the research area.

Fig 2: ABEM Terrameter SAS 4000

In VES, middle point remains fixed but other points are flexible. Rods were also placed at 0.5 m, 5 m, 10 m and 20 m. Schlumberger arrangement is used in this survey. VES data was then computerized in excel sheet. Excel sheet was then imported in IX1D software. To bring R M S error less than 5% between field data and the synthetic model curve, iterations were held. Model was then imported in ArcMap to determine water quality at various depths.

III. RESULTS AND DISCUSSION

Out of 18 node points, four nodes; 2, 7, 8, and 17 are selected randomly to describe the groundwater availability and its quality for the selected distributary. These results are described and discussed as follows:

i. Node 2

The resistivity or VES data for Node 2 has been transferred to IX1D software to develop a 3 layered model (see Figure 4). It indicates towards presence of unsaturated layers above water and bedrock below layers below water table with freshwater in first two layers. In its third/last deep layer, there is a good quality of fresh groundwater with sand. This node point was surveyed near by the Naseer branch canal and it is the area, where one of historical course of the Indus River was flowing. The river sand was also observed while interviewing with the local people and clay. Here, we assure the good quality of groundwater, which is the fresh zone and farmers have installed number of tubewells for extracting the groundwater and having about 200 percent irrigation intensity.

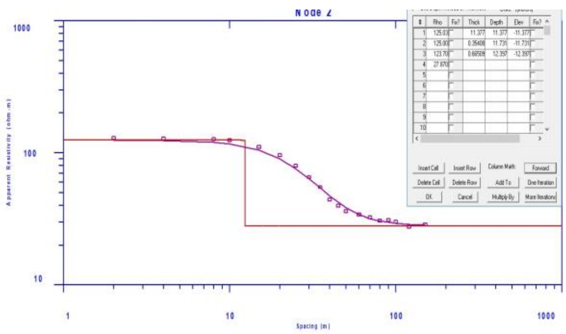

Figure 3. IX1D model for the Node 2 with various layer

ii. Node 7

From the resistivity/VES data of Node 7 resulted a 4 layers model using IX1D software. Its three layers (as shown in Figure 5) indicate that there is existence of sand and clay with marginal to fresh groundwater. However, its fourth layer steers towards existence of fresh groundwater.

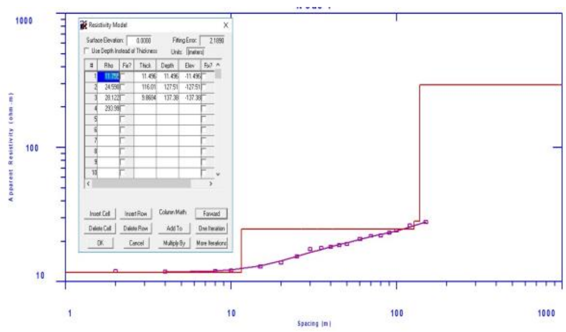

Figure 4. IX1D model for the Node 7 with various layer

iii. Node 8

Node 8 resulted in 4 layers model. It highlights presence of coarser material with good quality of groundwater. The middle portion of 3 to 6 m depth show some deteriorated groundwater which may be due to seepage from the some polluted domestic effluent. On the contrary, In the last layer, there is existence of sand and some clay with fresh groundwater.

iv. Node 17

Data for Node 17 has been imported to IX1D software which has resulted in 4 layers model. The model shows lowest resistivity among all layers (Figure 7). It's the first three layers indicates that there is existence of clay with little amount of sand. It also indicates presence of some marginal saline water. However in its layer four, the resistivity directs towards the presence of marginal fresh groundwater, which could be utilized through mixing with canal water for irrigating the agricultural land.

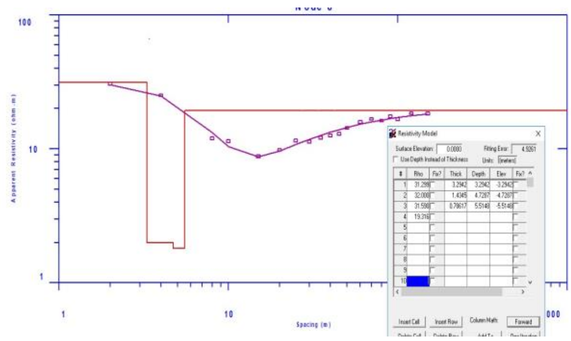

Figure 5. IX1D model for the Node 8 with various layer

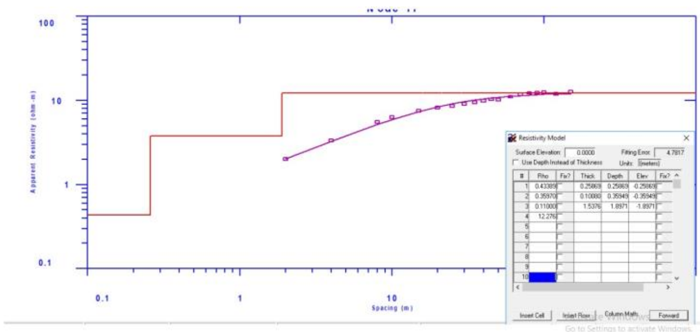

Figure 6. IX1D model for the Node 17 with various layer

Summary of the Node Points

The resistivity values for the above 4 node points are summarized as follows to show the minimum and maximum resistivity. The maximum resistivity show the existence of fresh groundwater, and the minimum value indicates the marginal saline water (Table 2).

Table 2: The high and low resistivity values for the selected 4 nodes

S. No	Nodes	High Resistivity (Ω-m)	Low Resistivity (Ω-m)	Location
1	2	125.03	27.87	Yousaf Halepoto
2	7	293,99	11.75	Mehro Keerio
3	8	19.04	8.9	Ali Hyder Jarwar Ali
4	17	12.27	0.11	Saleh Halepoto

Water quality maps, which were obtained from ArcMap at various depths, are following

- *At 50 m Depth:*

At 50 m depth, water is fresh and marginal fresh at head and mid of the distributary. It is saline and marginal saline at tail as shown in (figure 7).

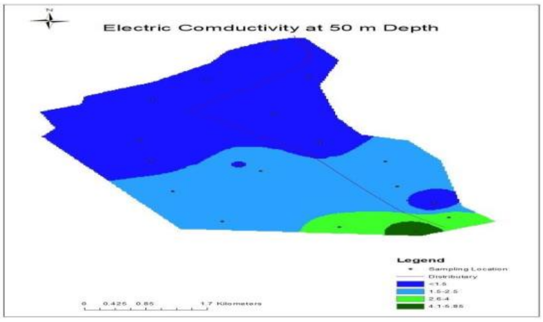

Figure 7. Water Quality Map at 50 m Depth

- *At 100 m depth*

At 100 m depth, water is marginal saline. However, there are few pockets of fresh and marginal fresh water as shown in (figure 8).

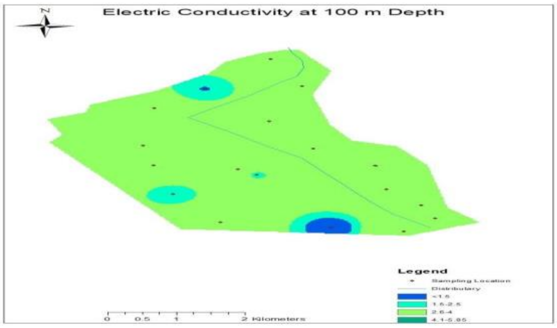

Figure 8: Water Quality Map at 100 m Depth

IV. CONCLUSION

It is concluded that there is presence marginal fresh groundwater in the upper layer which is not suitable for irrigation purpose. However, the last layer of fresh groundwater up to 150 m was observed as suitable for irrigation purpose. During the survey, number of functional tubewells were observed in the command area of Tando Allahyar-II distributary.

The resistivity survey clearly show that the nodes/areas surveyed nearby the canal, the groundwater quality in the upper 30m was marginal fresh, otherwise these showing tendency towards marginal saline.

V. RECOMMENDATION

It is recommended that groundwater of Tando Allahyar-II distributary command area below 30 m is mostly acceptable for irrigation purpose. However, it is suggested that some regulatory authority be developed to control the extra-ordinary extraction of the groundwater in the study area.

VI. ACKNOWLEDGEMENT

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