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Over Exploitation of Groundwater Resources and Their Influence on Groundwater in Peshawar Valley

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Abstract
In this study the objective is to find the impact of the rainwater recharge on the ground water table fluctuations. For this purpose the data about different sources of discharge from the ground water as well as the sources of water recharged into the ground water was collected. The discharge of these Tube wells ranges from 1200 gallons per hour for a Tube-well in Pishtakhera Payan to 50625 gallons per hour from an Irrigation Tube well in Lakaray. It was also observed that both turbine and submersible pumps are used in these tube-wells. After summing up all the discharges from all the tube wells it was found to be 7,401,684 gallons per hour (7.78m^3/sec). According to PDA report area of Peshawar is 1257 Km^2. Since Depth of water per unit time is total discharge / total Area, therefore depth of water per second is 7.77 / (1257*1000^2) = 6.18 * 10^{-9} m/sec. Depth of water per year = 6.18 * 10^{-9} * 3600*12*365= 0.098 m /year= 98 mm / year. The average discharge of each commercial well was found to be 0.38 Liters / second. Since ttal number of union councils in Peshawar region are 92, therefore on average total number of commercial/community tube wells are 552. Taking average discharge for each tube well as 0.38 Liters / sec, total discharge from the commercial wells in Peshawar region will be 552*0.38=209.76 Liters per second which is equal to 0.2098 cubic meter per second. Discharge from commercial wells per year=0.2098*3600*4*365= 1102498.6 cubic meter per year.Total depth of water discharged by the commercial wells from the Peshawar region is Depth of water = 1102498.6 / 1169*1000^2=0.94mm/year.Assuming two hours operation of hand pump daily, total outflow of water from town-II is equal to 22873905.7 cubic meters per year. Total depth of water discharged from town-II using hand pumps was found to be equal to 52.28 mm per year.So total annual depth of water discharged out through hand pumps from three towns (II, III, and IV) is equal to 171.05 mm.
Keywords: Rainwater, Recharge, Hand Pump, Tube well, Discharge, Total Depth

INTRODUCTION

Ground water is the sub-surface water that exists at pressures less than or equal to the atmospheric pressure. Some 97 % of the world's potable water supply available at any moment occurs as a ground water; however the importance of ground water in the whole water Resources is undeniable. Peshawar region consists of Peshawar city, Cantonment Area, Hayatabad Town, University Town, University Campus and adjoining fringes rural areas. This has now been divided in to four towns. Peshawar, being the capital of Khyber Pakhtunkhwa, has a dense population with a large number of Afghan refugees. The estimated population of Peshawar is about 1.5 million which includes about 0.5 million-afghan refugees (Censes report 1998).The Water Table is best defined as the surface on which the fluid pressure in the pores of the porous medium is exactly atmospheric. The location of this surface is revealed by the level at which the water stands in a shallow well open along its length. If the discharge is greater than the recharge in an area then there will be depletion of water table and vice versa. Husain (2002) concluded that there is a serious problem of falling Water Table in the Junejwala where it falls at the rate of 0.3 m / year. Moreover the future trends indicate that if not properly monitored, it may have serious repercussions because the farmers of the area are fully dependent on Agriculture and there are no institutional arrangements to address the ground water management issues.Andrew and Hazim (1999) reviewed the regulatory measures being used in Jordan for the control of ground water depletion. A cording to these regulations, the groundwater abstraction has to be reduced by 60 % in high land areas for sustainability of ground water. The significant reduction in ground water withdrawal has been achieved by enforcing regulatory measures. The issuing of license, installation of flow meter on all existing wells, strict monitoring and imposition of penalties in case of violation has been used as regulatory measurements. Gates (1992) developed DRAINMOD model which shows that drainage outflows and Water Table elevations from Carteret forest watershed site (1988-1989) agreed well with the measured data. Estimated drainage volume by this model for that year was within 2 to 9 % of the measured cumulative volume while the deviation in Water Table levels was only 20 to 22 cm. Kruesman and Naqvi (1988) concluded that the depth of Water Table in Peshawar valley decreases by 30 to 40 m near the mountains to less than 0.5 m along the Kabul River where water logged conditions prevails.Malik (1967) published a report about the Water Table in Peshawar valley and concluded that in long-term series the Water Table has risen since the start of the observation i.e. since 1963. Rainfall does not have much influence on the groundwater levels. In the waterlogged areas the influence of the

evapotranspiration on the Water Table was appreciable. Karnath (1987) developed an equation that can be applied to compute the Water Table fluctuation for the year for which only the rainfall data is available.For this purpose, a large quantity of water drawn out from the ground water storage of Peshawar region by various agencies i.e. Municipal corporation Peshawar (MCP), Peshawar Development Authority (PDA), Public Health Engineering Department (PHED), Peshawar Community Development (PCD), Military Engineering Services (MES), Irrigation Department and Private Dug Wells or Hand- pumps was calculated.

MATERIAL AND METHODS

Measurement of out flow from the Peshawar region:

Discharge is volume of water drawn per unit time in case of Tube wells and is flow of certain volume of water per unit time in case of canals and streams. Usual units are gallons per hour and liters per sec.
The discharge from the Peshawar region is mainly due to pumping for irrigation, drainage, domestic use, and industrial purposes.
In this study, discharge from the following components of the outflow is estimated.

- Discharge from the Government Tube-Wells (Public health Engineering (PHED), Peshawar Development Authority (PDA), Cantonment Board, Military Engineering Services (MES) and Irrigation Department).
- Discharge from the commercial Tube-wells
- Discharge from the Dug-wells and hand-pumps in the rural areas of Peshawar region.

Discharge measurement from the entire components mentioned above is discussed below

a. Measurement of Discharge from Tube Wells operated by government departments:

For the calculation of discharge from the government Tube-wells, the data was collected from different government Departments including PHED, Irrigation Department, PDA, Town Municipal administration (TMA's), Cantonment Board, and MES. The number of tube wells collected from each department is as shown in Figure-01 below.

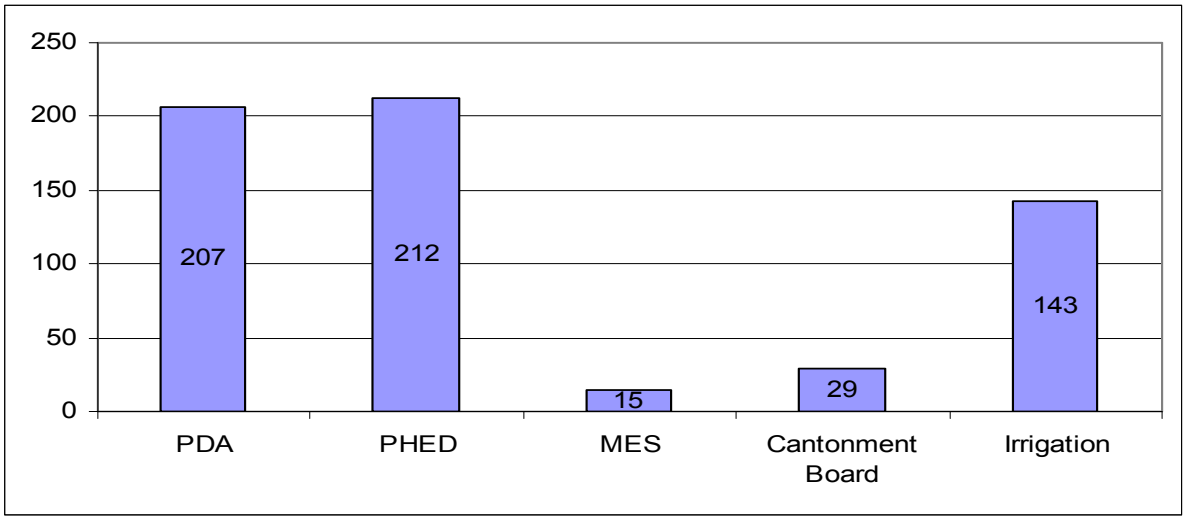

Figure 1: Tube-Wells Data collected from different Departments

Measurement of Discharge from Commercial/community tube wells:

There is no data available in any department about the commercial/community Tube wells and its discharges. To find out the number of such tube wells and its discharges a survey was conducted.. During survey the discharge of each commercial well was measured and then the average discharge of all such wells per union council was calculated. On average six commercial tube wells per union Councils were found in Town-I, II, III & IV. The average discharge of each commercial well was found to be 0.38 Liters / sec. knowing the number of commercial wells and discharge of each well, total outflow per year was calculated which was then converted into the annual depth of outflow through commercial wells.

b. Measurement of discharge from hand-pumps in Peshawar region:

In rural areas, most of the people did not have access to the water from the public tube wells; therefore these people dig their own wells (hand pumps) and extract water from the ground affecting ground water storage. Since no record on number and discharge of such hand pumps is available with any government department, therefore a random survey was conducted in number of union councils located in rural areas of town II, III and IV to measure the depth of water extracted by these hand pumps from ground water. During this survey, depth of water table and discharge of each hand pump was measured along with number of people served by each pump.

In town-II, the survey was conducted in five union councils including Chamkani, Budhni, Wadpaga, Nahaqi and Khazana. From these union councils a sample of homes was selected and the discharge of hand pump in each home and the number of persons served by that pump were found. From this data, the average outflow per person was calculated for each union council and then for each town. The same procedure was adopted for measurement of flow depth discharged through hand pumps from five UC's (Deh Bahader, Dheri Baghbanan, Pawaka, Malkandir and Bazid Khel) of town-III after collecting the required data from survey. The same way depth of water discharged from town-IV through hand pumps was also calculated. Total depth of water discharged through hand pumps from Peshawar region is then calculated.

c. Measurement of outflow from Dug Wells

The data for the dug-wells was obtained from Irrigation Department. Total number of Dug wells in Peshawar region is sixty three (63) having total discharge equal 0.642 m^3/sec. As these dug wells are spread over whole Peshawar region, therefore depth of water discharged.

RESULTS AND DISCUSSION

In this study the objective is to find the impact of the rainwater recharge on the ground water table fluctuations. For this purpose the data about different sources of discharge from the ground water as well as the sources of water recharged into the ground water was collected. The main source of recharge from Peshawar region is tube wells, dug wells and hand pumps. The data for the tube wells and dug wells was collected from different government departments but since nor record of hand pumps and commercial or community wells is available, therefore for this purpose a survey was conducted and the required data was collected. Similarly, since rainfall is the major source of recharge into the ground water therefore the rainfall data was collected from PAF as well as Meteorological department. But since the data from PAF is more reliable therefore it was used for the calculation of recharge to the ground water. In the following section the data collected for discharge as well as recharge will be presented and discussed.

Analysis of Outflow data:

The outflow components are government tube wells, dug wells, community tube wells and hand pumps. The data collected for all these components is discussed below.

d. Measurement of Discharge from Tube Wells operated by government departments:

As discussed earlier that the data for the tube wells was collected from different department. After thoroughly studying this data, it was observed that the discharge of these Tube wells ranges from 1200 gallons per hour for a Tube-well in Pishtakhera Payan to 50625 gallons per hour from an Irrigation Tube well in Lakaray. It was also observed that both turbine and submersible pumps are used in these tube-wells. The submersible pumps are those which are installed within the Tube-Well submersed in water and draw water from below while the Turbine pumps are installed on the earth surface and draw the water from below. Figure-02 below compares the number tube wells run by turbine and submersible pumps for the data collected from different departments.

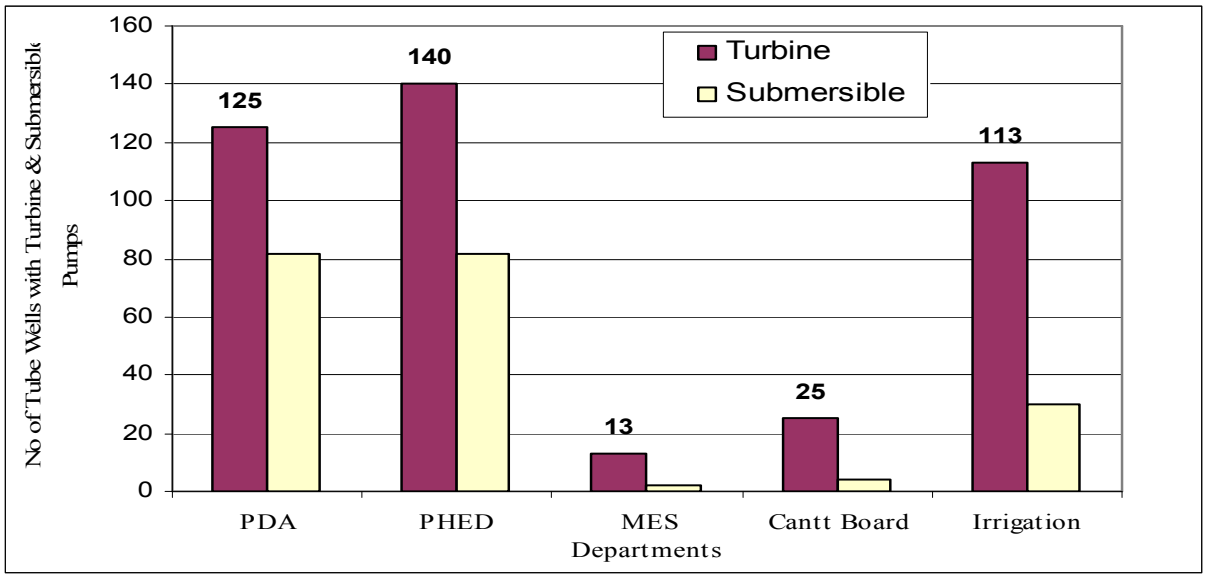

Figure 2: Comparison of Tube wells with Turbine and Submersible Pumps

The power (horse power) of pumps used in the tube wells of Peshawar region ranged from 15 HP to 60 HP. One motor with 30 &/or 40 HP are most frequently used.

For analysis purpose, the Peshawar district is divided into four independent towns (Town-I, II, III and IV) and cantonment area. Town-I and II each is further subdivided into 25 Union Councils (UC) while Town III & IV

each is divided into 21 Union Councils. The number of all the Union Councils in each town is shown in figure-3 below.

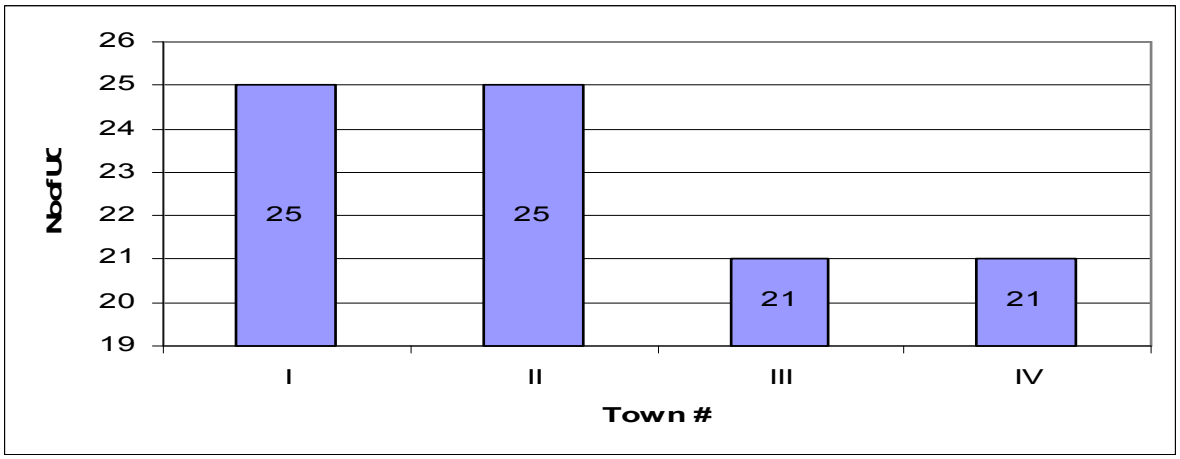

Figure 3: Number of Union Councils in each town

The total number of Tube-wells in study area is 670 which are then distributed in four towns and Cantonment area as shown in Figure-04 below.

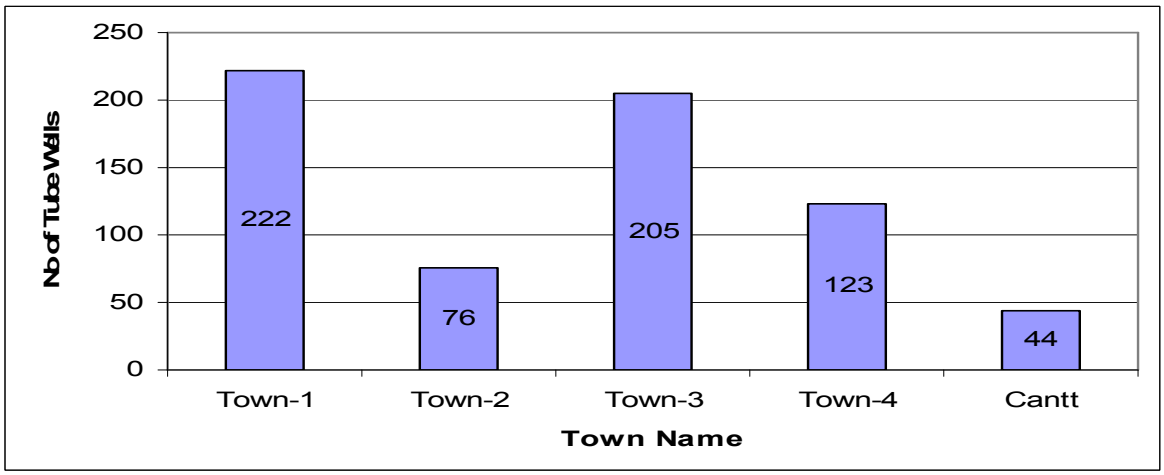

Figure 4: Town wise distribution of tube wells

After adding up the discharge of all the Tube-Wells located in each town and the Cantonment area, the total discharge was calculated as shown in table-02 below

Table 1: Town wise distribution and its corresponding total discharges

S.NO	Location	Total Number of Tube-Wells	Total Discharge (gallons / hour)
1	Town-I	222	2113595
2	Town-II	76	959115
3	Town-III	205	2,471,325
4	Town-IV	123	1399649
5	Cantonment Area	44	458000

After summing up all the discharges from all the tube wells it was found to be 7,401,684 gallons per hour (7.78m^3/sec). According to PDA report area of Peshawar is 1257 Km^2. Since Depth of water per unit time is total discharge / total Area, therefore depth of water per second is 7.77 / (1257*1000^2) = 6.18 * 10^{-9} m/sec.

Since in Peshawar region normally the tube wells operates for twelve hours a day therefore the depth of water discharged by the government tube wells in one year will be:

Depth of water per year = 6.18 * 10^{-9} * 3600*12*365= 0.098 m /year= **98 mm / year**

e. Measurement of outflow from Dug Wells

The data for the dug wells is collected from irrigation department. Total number of Dug wells in Peshawar region is sixty three (63) having total discharge equal 0.642 m^3/sec. As these dug wells are spread over whole Peshawar region, therefore depth of water discharged. Depth of water discharged = 0.0161 m/ year or **16.1 mm / year**

f. Measurement of Discharge from Commercial/community tube wells:

As discussed earlier that a survey was conducted to find the number of community wells and its total discharges. From survey, it was found that there are on average six commercial tube wells per union Councils in each Town. The average discharge of each commercial well was found to be 0.38 Liters / second. Since total number of union councils in Peshawar region are 92, therefore on average total number of commercial/community tube wells are 552. Taking average discharge for each tube well as 0.38 Liters / sec, total discharge from the commercial wells in Peshawar region will be 552*0.38=209.76 Liters per second which is equal to 0.2098 cubic meter per second. Operational time was not known but from the local people it was found that roughly it operates for about four hours per day. Hence the total discharge from the commercial wells per year will be:

Discharge from commercial wells per year=0.2098*3600*4*365= 1102498.6 cubic meter per year. Since there were no commercial wells found in cantonment area therefore to calculate the depth of water discharged by the commercial wells from the Peshawar region, the discharge per year will be divided by the total area of four town only which was found to be equal to 1169km^2.

Total depth of water discharged by the commercial wells from the Peshawar region is Depth of water = 1102498.6 / 1169*1000^2=0.94mm/year.

g. Measurement of discharge from hand-pumps in Peshawar region:

The survey was conducted to find the discharged depth by the hand pumps located in Peshawar region. Since town-I is fully urban therefore no hand pumps were found there. In town-II, the survey was conducted in five union councils including Chamkani, Budhni, Wadpaga, Nahaqi and Khazana. Almost 25% of the people of Town-II are using water of hand pumps. The total outflow from town-II through hand pumps was calculated by multiplying the per persons flow rate per year with the 25% of total population. It was found that in all five UC, the total outflow from hand pumps serving 202 peoples is 9.63 Liter/sec resulting in per capita consumption 0.0477 liter/seconds. The total population of town-II in 2006 was 7, 29,981 persons but since only 25% of people are using hand pumps as source of water, therefore the total outflow through hand pumps from town-II is 8704 Liters per second.

Assuming two hours operation of hand pump daily, total outflow of water from town-II is equal to 22873905.7 cubic meters per year. Total depth of water discharged from town-II using hand pumps was found to be equal to 52.28 mm per year.

Flow depth of water discharged per year through hand pumps from five UC's (Deh Bahader, Dheri Baghbanan, Pawaka, Malkandir and Bazid Khel) of town-III was calculated and was found to be 90.3 mm. For town-IV survey was conducted in five UC's and the resultant depth was found to be 28.6 mm/year.

So total annual depth of water discharged out through hand pumps from three towns (II, III, and IV) is equal to 171.05 mm.

So the total depth of water discharged out of the Peshawar region is the sum of depth of water discharged by government, commercial tube wells, dug wells and hand pumps. After summing all the above we get total depth of water equal to (98+0.94+171.05+16.1) **286.1 mm per year).** All the results can be summarized in Table-02 below.

Table 2: Discharges and corresponding depth of water discharged in mm per year for different components

Location	No of TW	Discharge (millions gallons per hour)	Discharge (m3/sec)	Total area (km2)	Depth discharged (mm/year)
Government tube wells	670	7.48	7.86	1257	98
Dug wells	63	0.611	0.64247	1169	16.118
Private wells	552	0.199	0.20976	1169	0.94
Hand pumps	N/A	77.8	81.8	1257	171.05
Total		**86.09**	**90.51223**	**1257**	**286.1**

CONCLUSION

The depth Discharged per year from the ground water storage of the study area was found to be 286.1 millimeter per year and is affecting the ground water storage. From the calculated Discharged and Recharged depth the change in ground water storage was calculated and was found to be -57 millimeter per year. The negative sign shows that more water is leaving the ground water storage which indicates depletion of water level in the area.

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