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Depletion of Water Resources, Issues and Challenges of Water Supply Management in Mazar-i-Sharif City, Afghanistan

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Abstract: This study was carried out with aim of providing valuable information for emerging water supply system management and better realize in water demand of Mazar-i-Sharif city**.** Most of the Mazar-i-Sharif city inhabitants lack an adequate, safe supply of water. Lack of water resources, management regulation, compounded by the recent year climate changes; In addition, lack of basic infrastructure, Moreover, extensively extent of urbanization, Issues and challenges in water management and increasing in population. The purpose of this study is to manage water resource for reasonable use of water supply system within the area. To this, large amount of data derived from 80 of water boreholes, like water level/Table, Type of geological materials, Hydraulic conductivity. In addition, hydrological data collected and analyzed. Due to reduction of aquifer recharge and precipitation 190 mm/year, progressing of population, increasing of water consumption; Thus, this study suggest, additional water resources for the area.

Keywords: Groundwater depletion, Mazar-i-Sharif, Afghanistan, water resources, water supply

INTRODUCTION

Water is an essential and natural resource for human life. The Mazar-i-Sharif city demand for water supply is met by two main sources: surface water (the Balkh River) and groundwater (the Mazar-i-Sharif aquifer). The city is located in the northern part of Afghanistan (within Afghan-Tajik Basin) about 425 km north of the country's capital city of Kabul . It is surrounded by Uzbekistan in the north , Sari Pul and Jowzjan Provinces in the southwest and Kunduz Province in the east. It is located at 67º.15́ Latitude and 36 º.42́ N Longitude and at an altitude of 378 m meters above mean sea level,). The study area covers an area of 100 km². Topographically, the state ranges in elevation from 320 to 420 m ASL, with a gentle slope toward the Amu Darya River. Mazar-i-Sharif's population has increased greatly during the last 10 years and accommodates 650.000 inhabitants (USAID, 2009) (Fig. 1 to 3).

Some geological and hydrological studies were carried out in Mazar-i-Sharif city area by Miskin (1968), Russian Scientists (1969-1997) and Radojicic and Arsalan (1979), the Afghan Geological Survey (AGS), as well as other international and local NGOs mainly for the development of water supply and similar purposes. Nevertheless, most of the information that emanated from those studies had been lost over the years due to the prolonged wars. Recent studies were made by Ashworth (2005) on groundwater and Russell *et al*. (2005) on seismic risk.

The developing residential in the study area and the increasing population growth has caused serious problems, particularly groundwater pollution and over abstraction. In the all supply wells within Mazar-i-Sharif city, particularly during the summer season the water level drops. As a result, Residents of Mazar-i-Sharif city facing with serous decline drinking water problems.

Scope of this study is to provide a preliminary information and characterization of the Mazar-i-Sharif hydrogeology and aquifer for sustainable manage of water supply demand of the Mazar-i-Sharif. This study is providing valuable data base of water supply of the city. Although, there are some limitation of research works, such as lack of laboratories and essential equipment; Therefore, the findings of the study could be applied to urban water supply center developments of the city which is currently in the process of reconstruction after three decades of civil war in Afghanistan. The main objectives of this study is to provide valuable data for emerging water supply system management and better realize in water demand of Mazar-i-Sharif city**.** Study of the groundwater resources within Mazar-i-Sharif Basin, to provide further insight and support in water resources management ;Moreover, to make preliminary data base on the quantity and quality of groundwater resources ;As a result, to Provide potential in possible water storage allocation options for the area.

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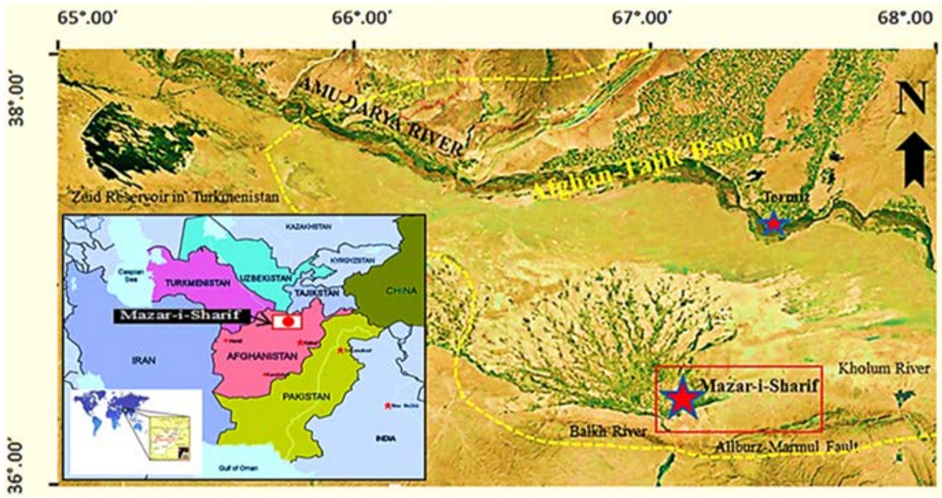

Fig. 1: Location of Mazar-i-Sharif city and Afghan Tajik Basin

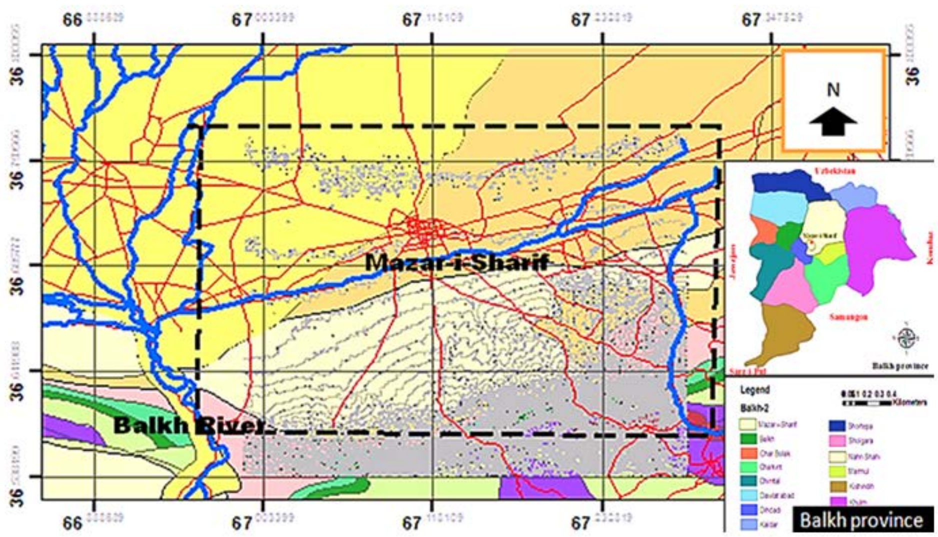

Fig. 2: Study area (Mazar-i-Sharif city)

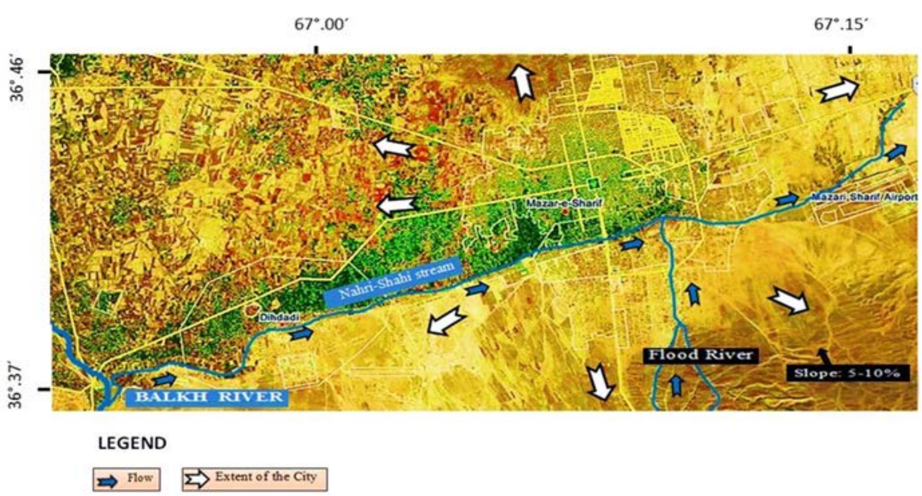

Fig. 3: The Mazar-i- Sharif city limit and extant

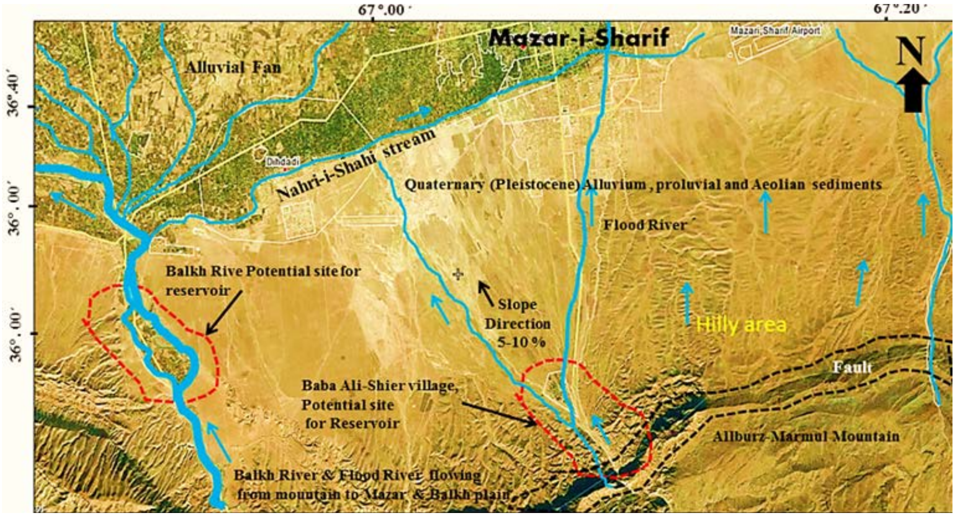

Fig. 4: Illustration of Surface condition of study area

Geology and hydrogeology: According to Miskin (1968) the Quaternary sediments that are 70 m thick close to Mazar-i-Sharif city, more than 170 m thick in the north(salty soil desert) of Mazar-i-Sharif and 90 m thick adjacent to the Amu Darya River. Near to study area the Quaternary sediments are dominated by gravels. Between Mazar-i-Sharif and the central part of desert the main sand, gravel and conglomerate aquifer is located near the base of the Quaternary sequence and for the most part is less than 20 m thick. In the central part of desert a series of sand horizons are shown inter bedded with clay, with the basal sands thickening rapidly towards the Amu Darya River. 20 km from this river the most of the cut section is West to East cross-section. This shows a hydro geological section running approximately 30 km east and 30 km west of the Balkh River close to and south- west boundary of the study Area. the Balkh River and more than 180 m thick, 10 km north-east of Mazar-i-Sharif Airport. This section indicates that the Balkh River in largely underlain by conglomerates where it debouches onto the plain. West and east of this river the Quaternary sediments appear to largely comprise a thick sequence of gravels, inter layered in places by clay. According to Radojicic and Arsalan (1979) close to piedmont on the south of the study area (Fig. 4) the thickness of the alluvium is 115 m in boreholes TW-340 and 123 m in TW -338 and over 265 m in TW-287, in Balkh City. The deepest thicknesses of Quaternary sediments were cut at TW-328 (286 m) and TW-322 (487 m), in the City of Mazar-i- Sharif. The average depth of Quaternary sediments was 108 m. According to Uhl (2003) the hydrogeology and geology of Northern River Basins, largely using information abstracted from the United Nations Development Program UNDP report of United Nations (1986). Recharge in the Northern River Basin was described and estimated using two methods. The first approach was based on the FAO's., (1996) method of estimating groundwater recharge as a fixed percentage (10%) of average annual precipitation. The second approach was to use a higher percentage of average annual precipitation of recharge in unconsolidated (Quaternary and Neogene aquifers) and carbonate rock systems, and a lower rate of recharge for consolidated bedrock. Irrigation application was assumed to be between 7,000 to 8,000 m^3/ha/year and domestic use appears to have been estimated at about 5 to 10% of the irrigation requirements.

The geological units of the study area, Quaternary aged alluvial, proluvial and eolian deposits covering the Afghan north desert. According to Radojicic and Arsalan (1979) and Ashworth (2005) the Quaternary deposits in the study area divided into two main units, like Alluvium deposits (Hilly area) and comprise terrace sands and gravels, with occasional cobbles , Proluvial depositsand cover most of the area. According to Miskin (1968) there are eight lithological sub-divisions of Quaternary deposits, according to Radojicic and Arsalan (1979) and suggested that only four of these deposits have hydro geological significance like Loam and sandy loam with inter-layers of clay and sand underlain by a continuous very thick shingle-gravel bed, Loam and sandy loam with inter-layers of clay and sand underlain discontinuously by shingle or intercalations of shingle sandy and dusty loam, often with inclusions of variously sized fragments of rock and loam and sandy loam underlain by inter-bedded clay and sand and in places by gravel.

According to Ronald (2005) the surface geology of the study area correlate with the soils; In the Mazar-i-Sharif city area founded, unit Q34a comprise from conglomerate and sandstone (Holocene and latePleistocene)-Alluvium; shingly and detrital sediments, gravel, sand, moreabundant than silt and clay). In the north of study area, interspersed within the Q34a zone, roughly in a semicircle, are found large patches of Q4sm like salt marsh deposits [Holocene] - mud, silt, clay, more abundant than sand; gypsum and salt. To the north of the area Q34a zone, unit Q3a predominates same description as Q34a except without the younger Holocene contributions. Further, north still, towards the Amu Darya, unit Q34e, Eolian deposits [Holocene and late Pleistocene] - Sand is found. In the Balkh river course from its entry into the lower Balkh system to its tail end past Aqcha, Unit Q4a is found (same description as Q34a except without the older Pleistocene contributions).

MATERIALS AND METHODS

The study was made based on the collected data and development of hydrogeological data. Site investigation including topography and surface geological information, water table/level and water supply networks, development of hydrogeology, deep wells data, shallow wells data, water supply system data, rainfall data and rivers of basins data;. The rainfall data has been collected from Aerologic deportment and Food and Agriculture Organization of the United Nations (FAO). In Table 1 shows the rainfall days from ten years average record, that mean the continuously rainfall data records were available since 2000 to 2010 and in Fig. 5 shows the Minimum, Maximum and Mean rainfall from Mazar-i-Sharif. The available data from 80 depth wells and shallow wells have the following

Table 1: The Mazar-i-Sharif rainfall days of ten years record (FOA, and Aerologic deportment)

	>0.00 mm			>0.1 mm			>3.00 mm			>5.0 mm		
Month	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean
Jan	15	10.5	6	16	9.3	5	8	4.6	2	5	3.1	2
Feb	15	9.5	5	15	8.8	6	7	4.1	1	5	2.5	1
Mar	15	10.6	4	14	9.9	4	9	4.7	2	9	3.4	1
Apr	12	8,4	4	11	7.7	3	7	3.5	0	5	2.1	0
May	8	3	0	6	2.7	0	3	1	0	2	0.6	0
Jun	1	0.2	0	1	0.1	0	0	0	0	0	0	0
Jul	1	0.1	0	1	0.1	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0
Sep	1	0.1	0	0	0	0	0	0	0	0	0	0
Oct	6	2.3	0	6	1.7	0	2	0.7	0	1	0.2	0
Nov	8	3.3	0	7	0.2	0	4	1.1	0	3	0.3	0
Dec	13	7.8	5	12	6.8	3	4	2.1	0	3	0.9	0
Mean/year	7.92	4.65	2	7.42	3.94	1.75	3.67	1.82	0.42	2.75	1.13	0.33
Total/year	95	55.8	24	89	47.3	21	44	21.8	5	33	13.5	4

	>10.0mm			>30.0mm				
Month	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Max rainfall during 24hours(mm)	Min rainfall during 24hours(mm)
Jan	1	0.4	0	0	0	0	18.2	0.1
Feb	3	0.9	0	0	0	0	21.3	0.2
Mar	4	1.6	0	0	0.6	0	27.6	0.1
Apr	2	0.6	0	0	0	0	26.1	0.1
May	1	02	0	0	0	0	0.8	0.2
Jun	0	0	0	0	0	0	0.2	0.8
Jul	0	0	0	0	0	0	0	0.2
Aug	0	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	6	0.3
Nov	1	0.3	0	0	0	0	11.3	0.3
Dec	1	0.3	0	0	0	0	27.3	0.2
Mean/year	1.08	0.4	0	0	0.5	0		
Total/year	13	4.3	0	0	0.6	0		

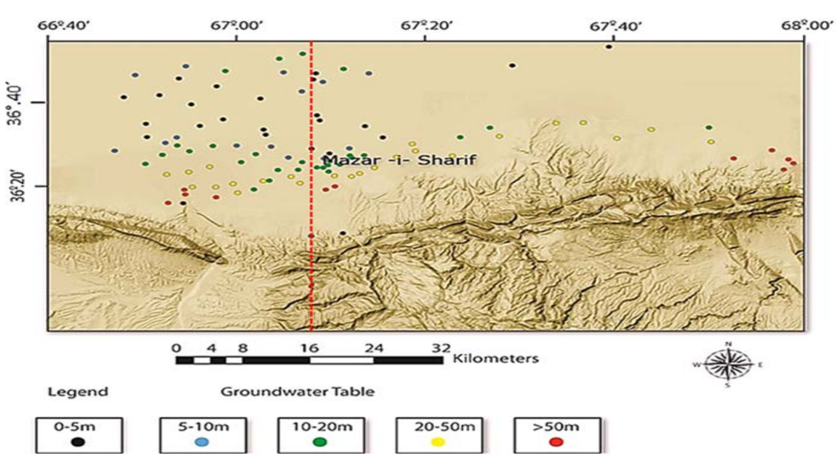

Fig. 5: The wells location and Groundwater table within study area

information: Location of wells, Depth of wells, Water head level from surface, Longitude of wells, Latitude of wells Altitude of wells. The surface and groundwater conditions derived from water wells and well logs, interview and as well as some laboratories works. In studying the topography elevation, the available topographic map of Mazar-i-Sharif based on the topographic map was used (Robert, 2005).

In addition, a water-budget of the Mazar-i-Sharif basin was developed on the base of conservation of mass according to precipitation P, surface-water discharge into Qin and out Qoutof the basin, evapotranspiration ET, change in surface-water storage ΔS and recharge R, according to the following equation:

$$P + Qin - ET \pm Qout \pm R \pm \Delta S$$

Consequently, estimate of the groundwater recharge R was made as a fixed percentage, namely 10% of average annual precipitation, (190 mm.year) and water samples were collected and analyzed.

RESULTS AND DISCUSSION

This study was made based on the water supply data and data derived from 80 water wells (Fig. 5), hydrogeological data (Table 1 to 4, Fig. 6 to 9); Obtained results from this investigation as following:

Water supply resources: In Mazar-i-Sharif City water for irrigation and drinking is provided from two main sources, namely, groundwater from shallow and deep aquifers and surface water from the Nahri-Shahi stream (Fig. 4). Based on hydrological investigation water well data were collected and groundwater aquifer system of the area is constructed. The shallow aquifer is considered to be divided into two zones brackish water and freshwater. In the north of Shrine Ali Tomb towards the north salty desert the aquifer was found to be mostly salty and unsuitable for human consumption but towards the Balkh River the aquifer has freshwater and is suitable for human consumption. The depth of this layer varies between 20-40 m towards Balkh District as well as the southern side, while it could be 100 to 120 m deep towards Charbulak district area. This signifies the alluvial and colluvial deposit of this basin. The colored and rounded gravel deposition within the basin shows that the sedimentary soils were transported over a long distance layer such a deposition. Based on field visits and investigation we found that within the basin in some areas the aquifer is running spring channels such as in the wells adjacent to Balkh University new campus or near Ali Abad residential areas. In addition, during the interviews with Vice president Eng. Mawlodeen of Oil and Gas Department of Mazar-i-Sharif we were told that close to the cross road of Mazar-i-Sharif to Kabul and Uzbekistan, the water table could drop below 150 m deep, But at the field of Sakhi campus groundwater can be extracted from 120-150 m depth, with a discharge rate of 31 l/sec as expected. In general, it becomes salty to the north. Deeper aquifers, at depths of 80-110 m are in general fresh. Consequently, at south of the city groundwater can be extracted from 60-90 m depth.

Table 2: Water quality and mineralization of Mazar-i-Sharif basin aquifer

Type of analysis	Unit	Min.	Max.
Conductivity	μS/cm	575	20300
PH	-	6.87	8.47 Alkaline
Nitrate	mg/L	0	1
Arsenic	mg/L	0	10
TDS		0.22	8.4
Bacteria	Ecol	1	2419.6

Table 3: Hydraulic conductivity

Material type	Description	Hydraulic conductivity, (m/s)		
		Kx (E-W)	Ky (N-S)	Kz
1	Holocene and late Pleistocene(sandstone)	6.34E-09	3.22E-09	4.23E-09
2	Holocene-(Sandstone)	4.50E-08	2.45E-08	4.45E-08
3	Holocene-(Mud, Silt and Clay)	3.35E-06	6.34E-06	4.11E-06
4	Middle Miocene-(Clay and siltstone)	8.70E-06	4.73E-06	3.37E-06
5	Middle Pleistocene-(Loess)	6.62E-07	3.62E-07	6.52E-07
6	Holocene and late Pleistocene-(Eolian deposit -Sand)	6.11E-03	3.12E-04	6.15E-04
7	Late Pleistocene-(sandstone)	6.61E-08	2.30E-08	4.52E-08
8	Shahar dorahi formation-(Sandy Silt)	2.12E-05	6.52E-05	3.19E-05
9	Shahar dorahi formation-(Gravely Sand)	1.00E-04	2.21E-02	3.31E-02
10	Shahar dorahi formation-(Sandy clay))	1.57e--5	2.35E-05	2.70E-05
11	Shahar dorahi formation-(Gravely)	1.00E-03	1.00E-03	1.00E-03

Table 4: The Balkh River (In Balkh water shade) flow rate (Food and Agriculture Organization of the United Nations (FAO) and Afghanistan Information Management Service (AIMS), 2004)

Watershed	Station name	Location: Latitude	Location: Longitude	Record period	Mean annual discharge (M. cum/yr
Balkh	Kishendah	36.1333	66.95	1978-1996	-
	Near Nayak	34.75	67	1978-1996	-
	Rebate Bala	36.5833	66.9667	1978-1996	1.65
Kholum	Saied	36.5833	67.7833	1964-1978	-
	Tangi Tashqurgan	36.6667	67.7000	1969-1978	60

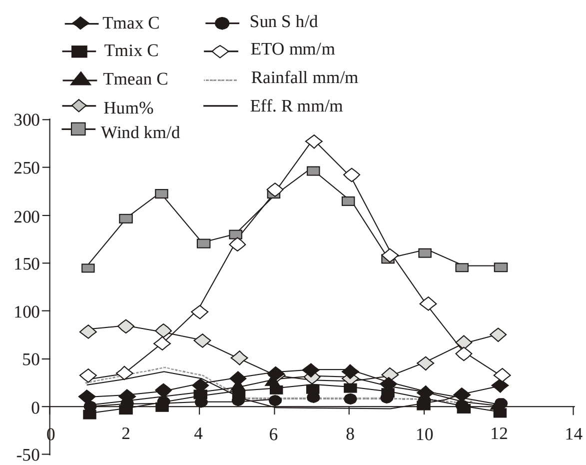

Fig. 6: Climatology graphic of study area, (twelve years record)

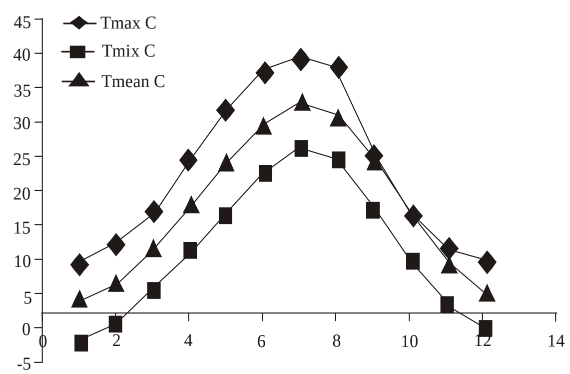

Fig. 7: The Maximum temperature, minimum temperature and the mean temperature of Mazar-i-Sharif city, (twelve years record), the maximum temperature shows at month of July (38.6 °C), and minimum temperature shows at month of January (-2°C)

The water supply system could be constructed or purposed at along the main road for 70% of Mazar-i-Sharif city (especially districts western part of city) (Fig. 10 and 11). The Balkh River flows into the area from the south-west. It is the main surface water source of Mazar-i-Sharif. This River and its tributaries flow through a series of gorges. The main headwater of the River is the BaBah Mountain (Bande Amir), consist of five lakes. It has an Altitude of 3750 m and the upper side of this River is very narrow. From this area the trajectory of the Balkh River changes from south to west (Favre and Kamal, 2004).The Balkh River is the source of many water streams within the alluvia fan area, like the Nahri-i-Shahi stream which carries the water supply from the Balkh River to the city, The Balkh River water used for irrigation and water supply purposes. In the future Amu Darya River can become additional source of water supply but it needs government investment.

The investigation found that mostly upper an unconfined aquifer is salty while the lower confined aquifer is suitable for human consumption. The summary of quality and mineralization of water in this basin is shown in Table 2; the water table is given in Fig. 5.The Mazar-i-Sharif tectonic step block, located to the north of the Allburz-Marmul (south part) displacement. At the end of the Neogene and beginning of the Quaternary, when the whole of Afghanistan was tectonically reconstructed, the Mazar-e-Sharif tectonic step block has deformed into a trough, which was later filled with Neogene and Quaternary deposits. However, the geological sections of focus are has been modified at below:

Lower Cretaceous K_1: In the study area, Cretaceous layer has been deposited after Jurassic. This layer has formed from different deposit materials such sandstone, conglomerate, gypsum and clay. It has been deposited from the (2495-3416) m depth and with 921 m thickness in underground. The layer mineralization of groundwater is about 20 g/L.

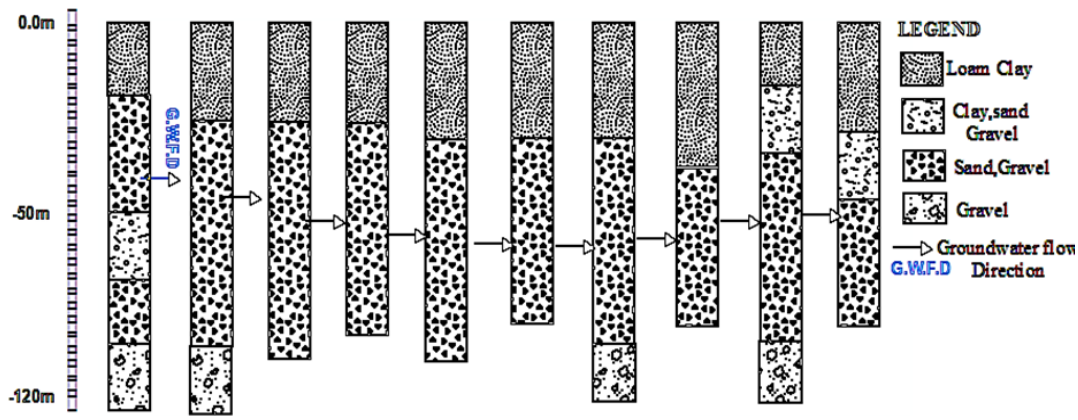

Fig. 8: South to north cross section

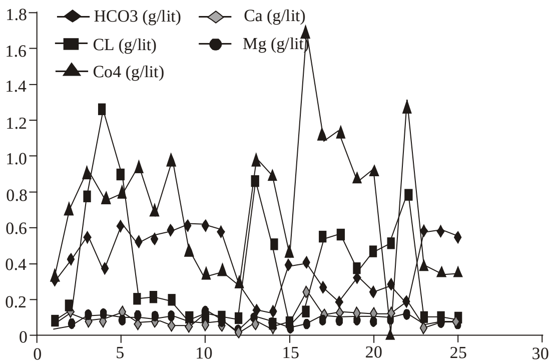

Fig. 9: Illustration of average chemical properties of groundwater from selected boreholes test data within the area

- **Upper cretaceous K_2:** This layer has been deposited upper K_2. It has been formed from sandstone, siltstone, marl, gypsum and abundant limestone. Therefore, it has deposited in (2495-1353) m depth and with 1142 m thickness. This layer groundwater has been mixed with oil and Gas on the depth. And it has mixed with kind of sulfur with calcite into ground.
- **Middle paleocene:** It has formed by clay, siltstone, gypsum, sandstone, marl and conglomerate.

This layer has deposited 500 m thickness with difficulty of geological term as well as with kind of depth fault. This layer has abundant siltstone it called

Fig. 10: General view of the study area

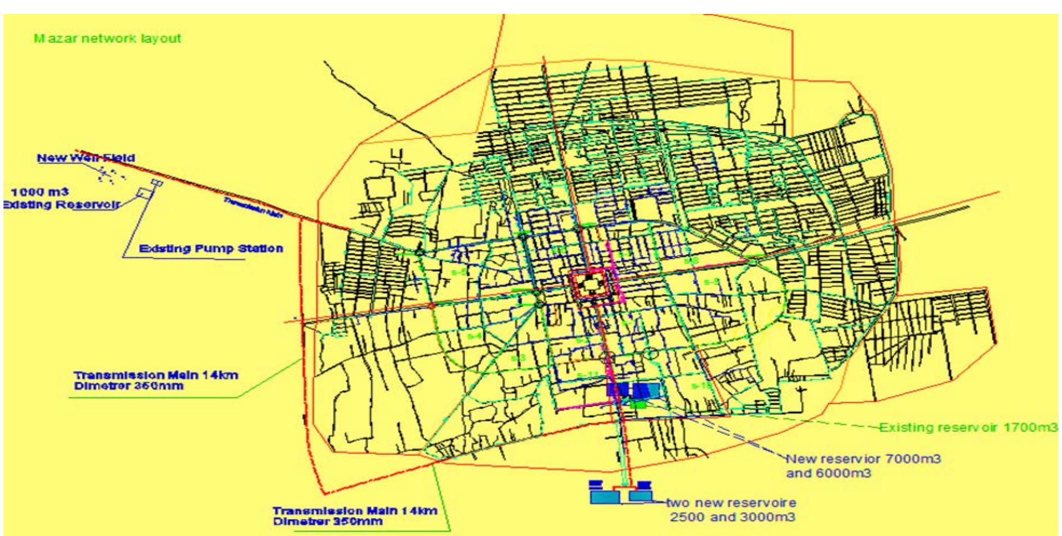

Fig. 11: The Mazar-i-Sharif purposed water supply map

Sweet Ghory. There is lots of pore with large potential of groundwater with 5g/L mineralization.

- **Lower Miocene:** The lithology of this layer has been formed by clay, sand-clay, gravel, gypsum and conglomerate with siltstone. It has deposited before Paleocene in the study area.
- **Holocene:** This kind of layer has abundant formed around the Mazar-i-Sharif city. The lots of area have covered from Q1, Q2, Q3 and Q4 with a thickness of 700 m. The lithology of this layer has formed with clay, sand-clay, gravel, conglomerate and with different sands. The layer has water from different depth because of geological condition. According to Danish Committee for Aid to Afghan Refugees (DACCAR) and National Survey Programs NSP., (DACCAR and NSP, 2010), the groundwater on the north part of study area is located to (6-25) m with high mineralization and little bit salty test. Unlike, the groundwater on the south is located to (25-120) m with low mineralization and good quality water for the different layers.

Geological layers and Groundwater condition in the study Area: In the study area the depth of study has envisaged about -120 m bellow the ground with ranges elevation of 300-460 m from MSL. According the geology of study area and aquifers description, The geological unites of cross section were modified and identified with description of bellow geological unites: Lower Cretaceous K_1,Upper Cretaceous K_2, Middle Paleocene, Lower Miocene and Holocene. By producing cross section (Fig. 8), we may judge that the groundwater flow direction has been fed from south part of area. And according MSL, the groundwater table on the south part is higher than north part, the ranges of groundwater table is 300-360 or 380 m from MSL.

The groundwater pressure on the south is farther then north. In conclusion, there are three key strategies which were useful and helpful to judge them for the understanding of geological condition, groundwater table from MSL and elevation of study area.

Average annual rainfall data from the study area is 190 mm/year. In the Balkh River valley there are two large springs: The spring on the left bank has a discharge of 3300 L/sec and temperature of 19.8 °C. The spring on the right bank has a discharge of 1522 L/sec and a temperature 18 °C. The study area is recharge of from many sources, namely, Balkh River, Kholum River (Table 4), Shadyan valley, Shoraab valley and Marmol valley. Discharges of boreholes within Mazar-i-Sharif varied from 0.6 and 24 L/sec and averaged 9 L/sec. Hydraulic conductivities at these boreholes varied between 0.23 and 6.8 m/day (Table 3).

In addition, based on direct field investigation, geological materials and some laboratory works, mal practice of water extraction and multi holies like depth wells and construction of nonstandard septic tanks are others cause of groundwater depletion and pollution of water sources within the area. Moreover, based on interview with president of water supply department and interview with inhabitants of the city, within past 20 years the groundwater level had been drawdown more than 2-3 m. The land use planning of urban areas must take into account the multipoint source of groundwater contamination. The risks of aquifer pollution are substantial and could affect the groundwater hydrology because the movement of water flow from south to north and dispersion within the aquifers could promote the spread of pollutants over a wide area and can seep into groundwater wells or into surface waters such as springs ruing channels closes to Balkh University new campus and Nahri-i-Shahi stream. Finally, Due to increase in population the future extent of the city, from 3-D groundwater flow (Fig. 12) and groundwater quality analysis (Fig. 9 and Table 2), finding the new water supply sources are important tool for the studied area like Takhtah-Pul (Fig. 10).

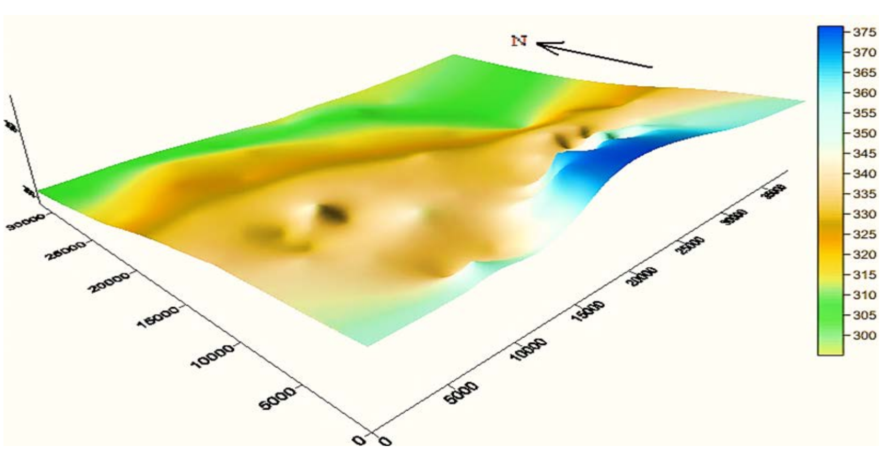

Fig. 12: Illustration of surface 3-D groundwater head level

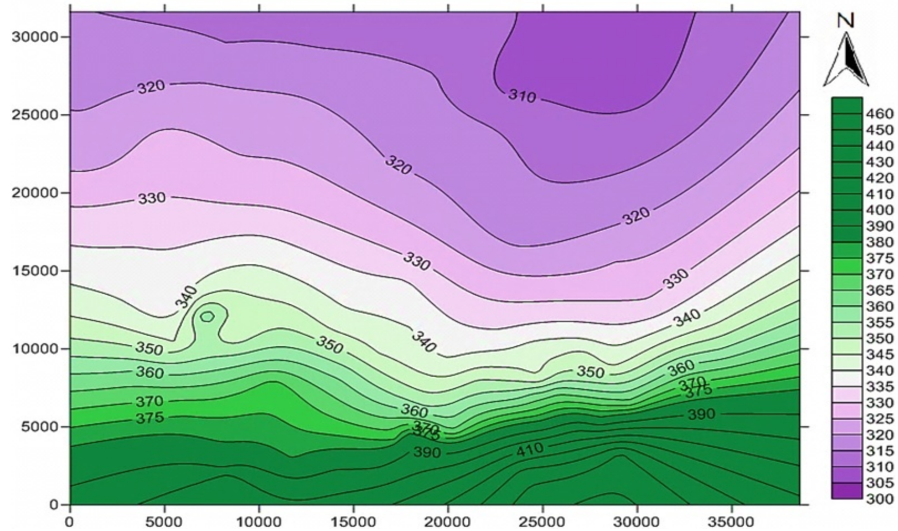

Fig. 13: Actual ground elevation from MSL

There are many local water supply networks. Almost all districts of Mazar-i-Sharif have individual water supply network. About fifty percent of water need of the city is covered by such water supply installments. Based on field investigation we found that many districts like Karta Sulah and Dashti Shuor have severe water shortage problems. The main water supply network is installed in the southern part of the city close to Nahri-i-Shahi stream. This main water supply network could fulfill the water demand of only about 30% of the population of the city living in the central and southern sectors. Due to poor quality aquifer, water supply has been identified as one of the major problems of the study area. Based on the field investigation and interview with the president of Water Supply Deportment of Mazar-i-Sharif it was found that the Takhtah- Pul area (Fig. 10 and 11) which is located in the west of Mazar-i-Sharif is a good source of water for city with capacities of 35 L/sec. In addition, there are two main potential reservoir sites harvesting and recharge of Mazar-i-Sharif aquifer, like Balkh River and BaBah Ali Shir; Finally, our study found that, the city has 650.000 inhabitants and the production capacity of Mazar-i-Sharif water supply department is an average 10.400 m^3/day, but the current demand, based on the city's population could be about 24.400 m^3/day, Hence the shortage of water in the city is around 14.000 m^3.

CONCLUSION AND RECOMMENDATIONS

The result of our investigation suggest that, the city of Mazar-i-Sharif already facing serious water stress due to rapid increase in demand, pollution and life style; According to our results of study, it is concluded that the geological condition of study area, which could be traced from the Pre-Jurassic era and part of the Cimmerian Platform, comprises the Neogene and Quaternary (Pleistocene) sediments and loess.

The geological and groundwater study of Mazar-i-Sharif city has provided some key insights on the aquifer parameters for urban in water demands by highlighting on the potential groundwater resource zones which needs consideration during the land use planning of the area. In this study, all data are processed by using the hydrological (Table 1 and 4 and Fig. 6 and 7) and groundwater analysis was performed where the results revealed that the groundwater of the studied Basin (Fig. 5) could be evolved that groundwater flow from south to north (Fig. 8, 12 and 13). Besides, unconfined aquifer is mostly brackish water and not suitable for drinking purpose, For example, at the north part of the city groundwater is mostly salinity (Fig. 12 and 13); Moreover, low of precipitation, 190 mm and mal practice of water extraction are other cusses of groundwater depletion within the area.

Moreover, based on interview with president of water supply Department and interview with inhabitants of the city, within past 20 years the groundwater level had been drawdown more than 3-5 m; Moreover, according to groundwater static level from surface elevation map (Fig. 10 and 13), the water flows from south to north or south to north-west. Refer to groundwater flow analysis the study area water has been fed from Balkh River, Kholum River, Shadyan valley, Shoraab valley and Marmol valley (Fig. 4). Production capacity of Mazar-i-Sharif water supply Department is an average 10.400 m^3/day, but the current demand, based on the city's population could be about 24.400 m^3/day, Hence the shortage of water in the city is around 14.000 m^3. In addition, due to low in precipitation and as maintained above shortage in the future the city will be facing with serious groundwater depletion problems. In addition, there are two main potential reservoir sites can be good sources of recharge and water harvesting area for the Mazar-i-Sharif aquifer, like Balkh River and BaBah Ali Shir (Fig. 1 and 4). Besides, finding the new sources of water supply are, such as the Balkh River, Takhtah-Pul (Fig. 10 and 11) and Amu Dray River is a Vitol tool of study area. Finally, making a major strategy, like reducing non-revenue water, more innovative approach for rainwater harvesting, finding new water resources and water saving devices are essential for the area. Therefore, it should be in priority and consideration of the city planners and decision makers

REFRENCES

Ashworth, J.M., 2005. Groundwater Assessment of the Downstream Sections of the Balkh and Kholum Watersheds. Retrieved from: www. ijens. org/Vol_ 12_I_06/1214406-8585-IJCEE-IJENS.pdf.

DACCAR and NSP, 2010. Hydrological Reports 2010. Retrieved from: http://earth. google. com/ support/ bin/answer. py?answer, (URL 2012).

FAO, 1996. Afghanistan, Promotion of Agricultural Rehabilitation and Development Programmes, Water Resources and Irrigation. FAO Project TCP/AFG/4552, November 1996, AREV, Retrieved from: www. vuawater. com/pages/ Afghanistan_ GW_Study.pdf.

Favre, R. and G.M. Kamal, 2004. Watershed Atlas of Afghanistan: Working Document for Planners. 1st Edn., Ministry of Irrigation, Water Resources and Environment, Kabul.

Miskin, L.P., 1968. Groundwater investigations for domestic and drinking purposes in northern regions of Afghanistan. Report on Results of Investigation Carried by the Hydro-Geological Division of the Oil and Gas Exploration Department, from June 1965 through March (1968) Mazar-i- Sharif, 1968.

Radojicic, S.S. and S.M. Arsalan, 1979. Balkh-Aqcha regional water supply scheme. Report on Groundwater Potential. Report prepared for the Democratic Republic of Afghanistan, by the Ministry of Public Health. WHO/ UNICEF Assisted Project.

Robert, G.B., 2005. Topographic Map of Quadrangles 3666 and 3766, Balkh (219), Mazar-i-Sharif (220), Qarqin (213) and Hazara Toghai (214) Quadrangles, Afghanistan. Retrieved from: http://www.usgs.gov/pubprod.

Ronald, R.W., 2005. Geological Map of Quadrangles 3666 and 37666, Balkh (219), Mazar-i- Sharif (220), Qarqin (213) and Hazara Toghal (214) Quadrangles Map, Afghanistan. Retrieved from: http://pubs.usgs.gov/of/2005/1093/A/index.html.

Russell, L.W., G.B. Charles, L.J. Margo and L.D. Richard, 2005. Seismotectonic Map of Afghanistan, with Annotated Bibliography. Retrieved from: http://www.usgs.gov/pubprod.

Russian Scientists, 1969-1997. Hydro-Geological Investigations Reports of Oil and Gas Deportment for North of Afghanistan.

Uhl, V.W., 2003. Afghanistan: An Overview of Groundwater Resources and Challenges. Uhl, Baron, Rana Associates Inc. USA, Assisted by Eng. M. Qasim Tahiri, Basic Afghanistan Services, Kabul.

USAID, 2009. Commercialization of Afghanistan Water and Sanitation Activity (CAWSA), Assessment Report Mazar-i-Sharif Water Supply (CAWSA). Retrieved from: www. ijens. org/Vol_12_I_06/1214406-8585-IJCEE-IJENS.pdf.

United Nations, 1986. Groundwater in Continental Asia (Central, Eastern, Southern South-Eastern Asia): UN-DTCD Natural Resources/Water Series No. 15. United Nations, New York, pp: 391.