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Urbanization impact in terms of quality and quantity of groundwater: Case study of Kabul city

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Abstract
Urbanization is a major geomorphic process affecting both surface and groundwater systems. The development of cities inevitably increases paved surfaces and roofs (termed impervious cover) and storm drains. Installation of a network of subsurface structures, including utility systems, is another necessary aspect of modern cities. Urbanization alters topography and natural vegetation, stream flows and flooding characteristics, temperatures both above and below the land surface. Major physical changes to the groundwater system include changes in water table elevation, changes in permeability field created by construction and utility system emplacement and altered groundwater recharge. Groundwater in Kabul city is in serious risk due to over obstruction, severe contamination by sewage and lack of recharge from participation as grounds natural form has changed to paved streets, roads and roofs which prevents storm water infiltration. In recent years Kabul has changed to a populated and rapid urbanized city worldwide which 85% of water supply in this city rely on groundwater which mainly obstruct from private shallow wells, beside many private water supply companies and households have deep wells with a depth of more than 200 m. Lack of control and policies from government or corruption makes facing this vital issue more challenging. Also lack of Sanitation wastewater collection, disposal and treatment system in the city and seepage of wastewater and directly absorbed by ground making it the main source of pollution for groundwater.
This research analysis describes the status and trends of Kabul city groundwater system and assess new solutions to meet future groundwater conservation. Results from analyzed data shows that groundwater levels are declining quickly (2.1 m per year) which district number 11, 4, 12, 13, 18 and some other districts are more affected to groundwater depletion than others. This pollution exceeds the maximum permissible values determined by WHO, ANSA and other standards.

Keywords: Storm drains, flooding, groundwater, sewage, shallow wells

1. Introductions
The provision of water supply, sanitation and drainage are key elements of the urbanization process. Substantial differences in development sequence exist between higher-income areas, where the process is normally planned, and lower income areas, where informal settlements are progressively consolidated into urban areas, but common factors are impermeabilization of a significant proportion of the land surface and major importation of water from outside the urban limits, with subsequent disposal of large volumes of wastewater. Sanitation and drainage arrangements are thus also fundamental to consideration of the urban hydrological cycle. They generally evolve with time but vary widely with differing patterns of urban development. In most developing towns and cities installation of mains sewerage systems lags considerably behind population growth and water supply provision [1, 2].
Urbanization causes radical changes in the frequency and rate of groundwater recharge, with a general tendency for volume to increase significantly and for quality to deteriorate substantially. These changes cannot be measured directly and are thus difficult to quantify. In turn they influence groundwater levels and flow regimes in the underlying aquifers, with equilibrium taking decades to be achieved [3-8].
After Taliban and start of new government in Afghanistan in 2000s, our people that had immigrated to neighborhood and other countries started to come back to Afghanistan especially to Kabul city for the fact of working and living. According UNHCR report published in Nov 2017, since 2002 over 5.2 million refugees mainly from neighbor countries have arrived back to Afghanistan, which more than 68% of them returned to Kabul and 4 other provinces (mostly to Kabul)1. This made Kabul city to a rapid urbanized city and was the fifth fastest-growing city in the world as of 2012 [9-13].

Uncontrolled urbanization and the growing population are essential challenges for the water management in urbanized regions of the emerging- and developing countries. The interaction between urban development and groundwater may be explained in the relation with the land use pattern and stage of city evolution on affecting the quantity and quality of groundwater.

This paper investigates the impact of urban growth in groundwater quality and quantity in Kabul city aquifer. This investigation is based on the collection of available historical data and supplemented by field and laboratory investigations.

2. Materials and Methods

In this research the author has used collected data from MEW and DACAAR which has been recorded since 2006 from 42 groundwater monitoring wells in different districts of Kabul city. Data collection was done by author from Mew and DACAAR during period of studying. The remainder of this report consists of water level summary plots for the 42 wells in the Kabul basin that are part of MEW and DACAAR monthly monitoring network. For each well, a short summary is given about the location and basic attributes of the well. Water level summary plots all have the same time scale, from 15-Nov-2006

3. Description of the Study area

Afghanistan is landlocked country located in heart of Asia, it has high mountains and sources of oil, uranium, precious metals, precious stones, water etc.

Afghanistan has enough water sources for its irrigation, water supply and energy production on its surface and in the ground but due to bad security situation in the last three decades most of its infrastructure partially or completely damaged. Due to the rapid urbanization in the Kabul city, the water table decreases every year.

This paper aims to study historic profile of groundwater in Kabul city, specify source pollutants of Kabul city groundwater and factors behind groundwater depletion.

4. Research methods

In paper, data collection was done by author from Mew and DACAAR during period of studying, Water level data were recorded in the Kabul basin by means of monthly manual measurements. A predetermined reference point was used to maintain consistency for the water-level measurements. The distance from the reference point to land surface was measured and recorded on the field form. The depth to water from ground surface was calculated by subtracting or adding the reference point distance from the water-level measurement. Water-table altitude can be calculated by subtracting the measured depth to water from the land-surface altitude.

The remainder of this report consists of water level summary plots for the 42 wells in the Kabul basin that are part of MEW and DACAAR monthly monitoring network. For each well, a short summary is given about the location and basic attributes of the well. Water level summary plots all have the same time scale, from 15-Nov-2006, through present, although not all wells have data for this entire period. The vertical axis for the plots displays the water level in meters below land surface, and the vertical axis scale is different for each well to display adequate detail of water-level variations for each well. Discrete water-level measurements are indicated with a solid diamond symbol; the discrete measurements relate to a solid line to indicate the trend in water levels at the well, although water levels could have varied by an unknown amount between the measurements. Continuous water-level sensors have been deployed at five wells in the Kabul Basin, and preliminary data from these sensors indicate that water levels do not vary substantially on an hourly or daily basis. Most of the water-level measurements are considered to reflect static conditions; however, in instances where water levels are thought to be taken under dynamic conditions (a pump is operating or has been operated recently), an open diamond symbol is shown on the x-axis to indicate that the water level is a dynamic water level.

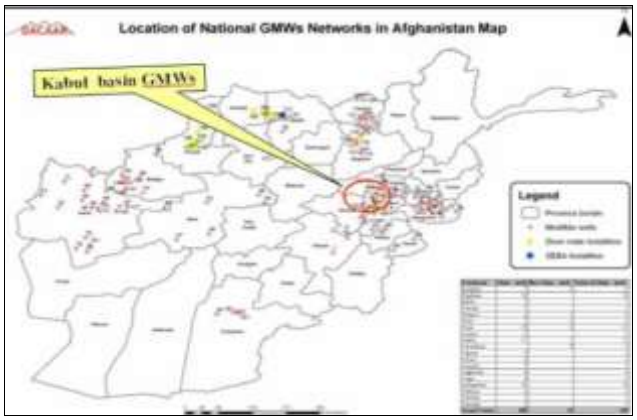

Fig 1: Location of National groundwater monitoring wells (GMWs) network in Afghanistan

Table 1: Groundwater Monitoring Wells

No	Well No	Well Name	Latitude	Longitude	El (m)
1	5	PD6, Salmaan Fars massjid Abbas Quli sub road	34.47834	69.105834	1842
2	6	PD6, inside Char Qala-e-Chahr Dhi School	34.48834	69.110834	1842
3	59	PD6, Sawdagar Bagh opposite Jaffaria masjid	34.48945	69.12945	1830
4	61	PD6, Sanatorium station Dar-ul-aman Road	34.473612	69.1225	1829
5	75	Deh Dana girls school	34.469167	69.134	1837
6	77	Shahid Abdul Qaiom Qudrat School	34.43945	69.129723	1850
7	79	Bahadur Khan school well	34.473612	69.09389	1873
8	80	Inside Zainab Kubra school compound	34.4923	69.08167	1872
9	B61	PD6, inside Cure medical hospital	34.470834	69.114723	1822
10	MW-18	Char Qala	34.48651	69.10533	…..
11	Bist Hazari	DACAAR Well opposite of Ab.Rahim School	34.49712	69.70835	…..
12	Bist Hazari	Private House (M.Ali)	34.49817	69.08125	…..
13	Bist Hazari	Husainya Jaghori	34.49319	69.08323	…..
14	Bist Hazari	Hazrat Abas	34.49204	69.08454	…..
15	Bist Hazari	Sai Bangi Private Pipe Network	34.51143	69.07368	…..
16	Bist Hazari	Private House (M.Azghar)	34.4922	69.08097	…..
17	Bist Hazari	Private House (M.Alam)	34.49105	69.07719	…..
18	Bist Hazari	Masjed Immam Mehdi	34.49734	69.08427	…..
19	GWM_2	DACAAR Office	34.55275	69.16004	…..
20	MR6	Kabul Jelalabad highway, Pul-e-Pachah	34.53586	69.21091	1784
21	85A	Qasaba, inside car wash compound beside reyasat well	34.57183	69.22562	1792
22	KN3	Panjsad family north of Qasaba street	34.58457	69.15015	1815
23	KN6	Mohammad Anwar Bismil school Panjsad family Khair Khana	34.58863	69.15442	1824
24	KN1	Inside Khair Khana zone well compound	34.58344	69.14603	1818
25	KN2	Russian streets new project	34.58508	69.14073	1821
26	KN4	Inside Abdul Qader Bedil school Khair Khana project	34.5882	69.13963	1823
27	CW1	Khwaja Boghra Park	34.56943	69.16322	1794
28	B137	Inside Haji Mohammad reza massjid Khwaja Boghra	34.57519	69.16521	1801
29	KN5	Inside Technical Services compound	34.57462	69.12954	1813
30	B114	Khwaja Boghra nest to Qasaba Street near Massjid	34.58397	69.16438	1808
31	MR2A	inside Milli Bus Authority, Mackroyan	34.52299	69.19805	1802
32	WA1	Infront of Emam Mohammad Baqir, Qala-e-Fathullah	34.55258	69.1608	1773
33	WA4	Aazmon private school well, Qala-e-Fathullah	34.54804	69.17056	1799
34	TW2	Inside Zarghona High school	34.54219	69.1693	1798
35	64	Klola Poshta, inside PD4 Police station	34.53864	69.15165	1794
36	KN9	Tahya Maskan Blocks, Badaam Bagh street	34.55472	69.12621	1796
37	WA3	Inside Ummar bin Khattab Deh Kipak, 90 family	34.54826	69.12633	1795
38	KN10	Inside animal vaccination farm, Badaam bagh	34.56176	69.12205	1807
39	WA2	Inside Abubaker Siddique Massjid, Taimani 2nd street	34.55478	69.15276	1799
40	MW1	AUWSSC well behind Abdul Haqq squre pump station	34.53371	69.20066	1813
41	59	Sawdagar bagh, PD6	34.48928	69.12955	1734
42	15	Inside Abu Talha massjid, Karte parwan	34.53987	69.138	1712

5. Sources and use of data

In this study, the data were used from Ministry of Energy and Water (MEW) and DACAAR for analyzing and calculation of groundwater. Number of populations has taken from UNHCR

6. Results

As this research studies Urbanization Impact on Groundwater Quantity and Quality, which is major factor behind groundwater depletion and changes in quality today Kabul city is facing. Collected data from groundwater monitoring wells in district 4, 5, 6, 10, 11, 16 and 18 which are most populated and improved in last decade, has been recorded since 2006. Groundwater fluctuation and changes in quality which has been monitoring and analyzed by MEW and DACAAR indicates below mentioned impacts:

- An overall average of 20.11 m depletion of groundwater table in studied districts of Kabul city.
- Increment in hardness, NO3, PO4, Magnesium, Electro conductivity, Total dissolved solids and other quality affecting components which can threat health of consumers.
- Kabul has turn to be one of most water stressed cities in the world.

7. Discussion

Since 2001, major cities in Afghanistan especially Kabul city have been expanded rapidly as the socioeconomic conditions were changed. So, this expansion has led to a massive increase in quantity of low-rise and high-rise buildings, according to municipality of Kabul from long times there is not any restriction on how to deal with water and wastewater management of all constructions.

Water wells and septic tanks are recommended for new residential constructed houses and there is not any specific rule for commercial buildings like high-rise residential, industrial or car wash constructions without any infrastructure project for water supply and sewerage networks that could manage water and wastewater. As a result, all buildings (low-rise and high-rise) constructed their own water wells and septic tanks for managing their water and wastewater, though lots of people using seepage

tank or absorption tanks as septic tanks and damaging water quality daily.

Increased water demand associated with urban and suburban growth can pose serious challenges to water sources of Kabul city, over discharge (pumping) of groundwater while no control by any governmental authority and absence of wastewater collection, treatment, and disposal systems, are caused depletion and affected quality of Kabul city groundwater.

5. Conclusions

In this research recent collected data was analyzed and compared to historic data of Kabul city groundwater hydrogeological and quality. The result suggests adverse change in participation, evaporation, temperature and consequently which has affected groundwater recharge.

Over pumping of groundwater by private residential households, companies and other consumers which have dug deep wells for usages of water. Author will specially point private water supply companies which has more than two deep water wells for over pumping of groundwater as there is no limitation or supervision by governmental authorities or corruption.

Kabul Basin natural groundwater systems are characterized by three hydro geologic units:

1. Crystalline rocks.
2. Upper Tertiary (Neogene) aquifer and aquitard system.
3. Quaternary sediments.

The crystalline rocks and Neogene sediments are not considered a major aquifer in Kabul Basin. Alluvial Quaternary sediments within the rivers channel are the most productive aquifers. These aquifers are affected by anthropogenic (human made waste) and pathogenic (microorganism) emission from various pit ways.

The recharge condition of the flow system is characterized by:

1. Recharges from Riverbeds.
2. Direct recharge from precipitation.
3. Foot hill recharge from snow melts.
4. Recharge from irrigation channels.
5. Recharge from percolation of sewage, leakage from septic tanks and pit latrines.

Kabul Basin groundwater main quantitative concerns are:

1. Declining water table exceeding the recharge trend
2. Depletion of natural storage
3. Water logging and salination
4. Perhaps land subsidence.

Kabul Basin groundwater main qualitative concern is:

1. Progressive increase of salinity with time.
2. Hard and very hard characteristic of carbonate hardness.
3. Progressive increase of nitrate concentrations with time.
4. Progressive increase of coliform bacteria.
5. Progressive increase of boron concentrations.
6. The high-rate presence of fecal coliform Bactria and high concentrations level of Nitrate indicates that Kabul Basin's drinking water systems are contaminated by fecal coliform (microbial pathogens) and nitrate (anthropogenic) contamination and pose a threat to the health of Kabul's inhabitants.

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