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Groundwater Pollution and Wastewater Management in Derna City, Libya

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Abstract: The study attempts to analyze the groundwater contamination and the health impact resulting from overflowing and leaking of municipal wastewater Derna (North-East Libya). About 3% out of 14798 families living in the study area were used as a study sample and distributed to them questionnaire using the Stratified Relatively Sample and Chi-square was used to analyze the statistical data. The 26 water samples were taken and analyzed chemically and bacterially. The results showed that there are approximately 29% of residents used of septic tanks to disposal their wastewater and about 40.5% of them do not discharge their tanks. And this has led with sewage overflowing from net work to leakage of pollutants to aquifers and has changed the groundwater quality. The bacterial analysis showed the significant increase of *E. coli* in most of water source, beside the increase of chemical elements that exceeded the maximum limits of standards of drinking water. The problem has caused some diseases such as incidence of intestinal, dermatologist, chest diseases, poisoning, cirrhosis of the liver and kidney failure but about (81%) of these diseases are intestinal diseases.

Key words: Bacterial pollution, chemical pollution, Derna, groundwater, sewage system, Malaysia

INTRODUCTION

Water is one of the most important resources bestowed by God Almighty for all humans, so it is assumed that this vital resource must have great interest and appreciation of humans and therefore, humans should seek to maintain and preserve its purity (Suleiman, 1992). In Libya, groundwater is the main source of freshwater, providing a vital supplement to surface water sources. Groundwater availability and quality are vulnerable both to climate change and over-abstraction. The lack of water reduces the ability to maintain quality, especially if there are multiple sources of pollution. There is almost no surface water or groundwater source without pollution and pollution normally does not cause many risk because its causes were not in fact only part of the ecosystem. The serious pollution to water sources started emerging at the beginning of spread of human activity on Earth.

Water pollution is any damage to the water quality in reducing its fitness for specific purposes. Accordingly, even when water is it polluted does not prevent usage in other purposes (Sharaf, 2000).

Water sources: Springs were the most important water sources of which were reliable in the region. In the study area there are two springs; spring of Elbelad produces between 40-100 M^3 S^{-1}. Spring of Bomansour produces between 120-250 M^3 S^{-1}. Both springs are located in basin of Derna valley in southern the region.

With urban growth, population increase and other human activities need for water exceeds the supply as depicted above. This prompted the authorities to between 1961 and 1976, to drill 10 wells with discharge capacity ranging 172-2700 M^3 day^{-1}; three more wells with capacity of between 240-300 M^3 day^{-1} were drilled in the same period and then followed by a series of drilling wells. However, >16 have been closed because breakdown of pumps or contamination of water and they are not suitable for human use.

Due to the persisting water shortage in water in recent times, it was considered to use seawater to meet water needs of the region through the establishment of two desalinations plants; Abu-Msafr plant, located near to the valley of Abu-Msafr 6 km west which produces 4600 M^3 day^{-1}. Munqar Rabeh, located 60 km outh-east

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Table 1: Rate of adoption of residents to water source

Water source	Percentage
Ground water	25.8
Desalinated water	73.3
Both	0.9
Total	100.0

Table 2: Productivity and consumption of water

Propose	Wells number	Productivity l/s	Consumption m^3 h^{-1}
Domestic	36	405.0	1440
Agriculture	54	266.0	920
Industry	51	177.5	612

GAW in 2003

the city and products about 30000 M^3 day^{-1} (Jumma, 2006). Since, the establishment of the desalination plant, majority of the populace have relied more on it as a source of water. This is shown in Table 1.

The population: Trend of population growth in Derna is not static. Between 1954-1964 it was 2.9% and increased to 5.9% for the period from 1964-1973 then the rate began to go down to 4.4% from 1973-1984 and this trend continued until it reached 1.6% in the period from 1984-1995 while in the period from 1995-2006 the rate increased slightly and reached 2.9% which suggests that population growth in the city characterized by instability (GAI in 1954, 1964, 1973, 1984, 1995, 2006).

There is a big gap between productivity and consumption of water in Derna region due to the increasing of population, urban growth and human activities (Table 2).

This study aims to analyze the groundwater pollution caused by sewage overflowing in Derna (North-East Libya) as well as to identify the health impact to the dwellers.

Study area: The city of Derna is located in the northeastern part of Libya in a narrow coastal plain between the sea and the northeastern slopes of the Al-Jabal, Al-khdar and the city is one of the most important urban centers in the Eastern region in terms of population.

Also it is location at the Sea Ras Almtarees where a seaport had been established this has increased its business as well as the presence of the most important fisheries of sponges near its shores which led to increase its economical importance (Habib, 1973).

Astronomically it is stretches between latitudes 32°43'40.10"N and 32°48'10.34"N and between longitudes 22°29'49.43"E and 22°42'32.94"E (Fig. 1).

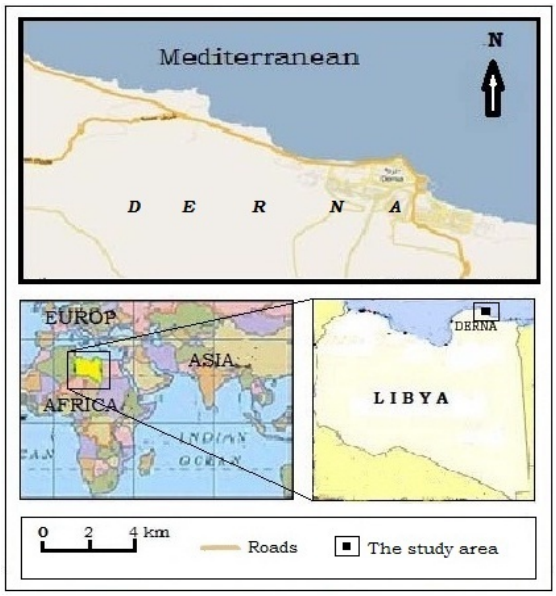

Fig. 1: Location of Libya and study area

MATERIALS AND METHODS

The study society includes of all families that living in the all parts of study area (Al-Maghar, Al-Belad, Al-Jubaila, Abu-Mansour and Al-Sahil) which contains of 14799 families. A minimum sample of 427 respondents was used in this study and it approximately represent 3% of all families that living in the region. Comprehensive questionnaires were designed and containing a series of questions related to the subject of study and distributed using the Stratified Relatively sample.

Most of the groundwater sources (wells and springs) had been counted and their coordinates had been determined as well using the Global Positioning System (GPS). Water samples from 26 water wells and two springs were taken in sample clean bottles. Seventeen of them were analyzed bacterially and eleven were analyzed chemically.

The Central Laboratory of Water in the Environmental Protection Agency was used for chemical and microbiological analysis of collected water samples and compare their result with global and Libyan standard specifications for water.

Water analysis has been carried out involving measuring the concentration of a standard set of constituents includes: PH, EC, T.D.S, T.H, Ca^{++}, Mg^{++}, Fe, NH_4, C1, NO_2 and PO_4 as well as the bacterial analysis. The Statistical Package for Social Science program (SPSS) was employed and used of Chi square (χ^2) to

analyze the statistical data and converted them into tables, percentages and graphics to link in between reasons and the results obtained.

RESULTS AND DISCUSSION

Sewage systems: Sewage systems are considered as the biggest source by volume of waste and pollutants discharged to the land. Urban wastewater systems can be also a source of many categories of pollutants including bacteria, viruses, nitrates from human waste, phosphorus, chloride and organic substances including organic solvents such as trichloroethylene that are used to clean the systems (Moody, 1996). Injection wells used for domestic wastewater disposal (Septic systems, cesspools, drainage wells for storm water runoff, groundwater recharge wells) are very big concern to water quality if located near to groundwater sources. Storing or disposing of household chemicals can lead to groundwater contamination, when stored in garages or basements with floor drains, spills and flooding may introduce such pollutants into the groundwater.

In Derna, there are two ways for disposal of wastewater: Septic tank and sewage network. Figure 2 and 3 show that 29% of residents rely on septic tanks to disposal their wastewater and 40.5% of them do not discharge their tanks and this method leads to leakage of pollutants to aquifers. The sewage networks were established in the sixties and no longer accommodate the current population density of the city and become dilapidated and spills out the sewage. From Fig. 4 could be shown that 67% of the respondents have acknowledge sewage overflowing as a problem they are experiencing and this have led to soil pollution and leaking to the aquifer. All sewage lift stations except one have been disrupted and exposed to neglect and stealing and finally become garbage landfill and thus polluted the beach and leaked to groundwater. Besides that the sewage treatment plant which was established in 1980, through its final stages have not completed then exposed to neglect and destruction and is now at a dilapidated stage with little actual value.

Change in groundwater quality was noticed by 67% of residents were residents as shown in Fig. 4 and 5. Preliminary examination of the data revealed that there is probability association between the groundwater quality change and the overflowing of sewage. Where 75.7% of residents have confirmed that there is a significant change in the quality of groundwater in the areas that have overflow of wastewater Table 3. Further analysis using chi-square method was carried out to identify whether the association between the groundwater quality change and

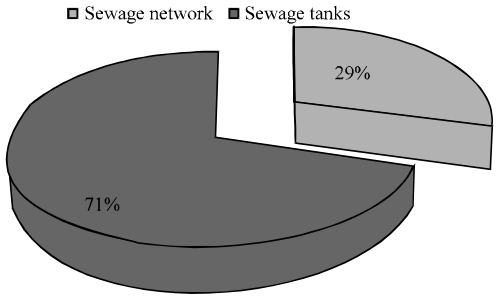

Fig. 2: Ways of sewage disposal in the city

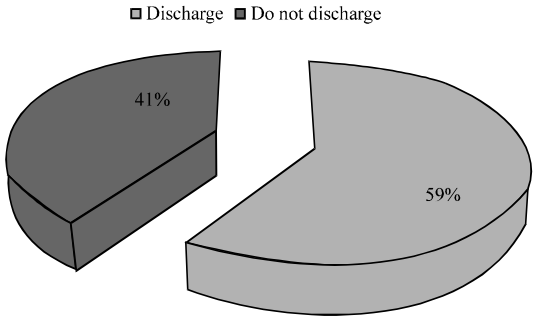

Fig. 3: Sewage tanks discharge

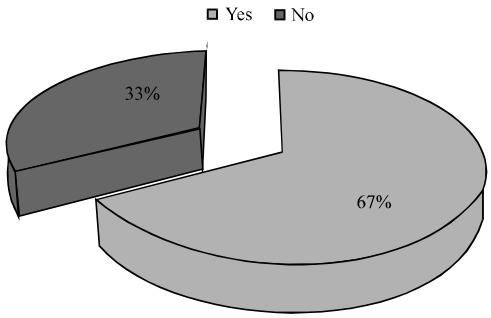

Fig. 4: Wage overflowing

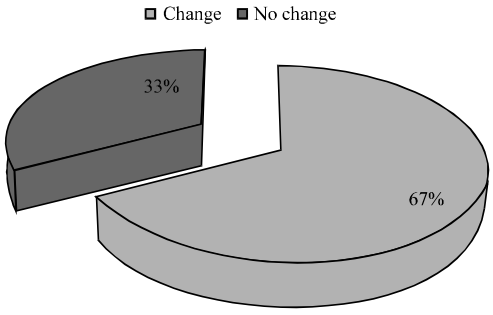

Fig. 5: Groundwater quality change

the overflowing of sewage is statistically significant. The analysis revealed a chi-square value of 27.407 which was significant at the 0.05 level ($p = 0.000$). Therefore,

Table 3: The relationship between sewage overflowing and water quality change in the city of Derna

	Sewage overflowing		
Water quality change	Overflowing	No overflowing	Total
Changed	218 (75.7%)	70 (24.3%)	288 (100%)
No changed	70 (50.4%)	69 (49.6%)	139 (100%)
Total	288 (67.4%)	139 (32.6%)	427 (100%)

Chi-square = 27.407, Significance = 0.000

this can be concluded that there is a significant association the groundwater quality change and the overflowing of wastewater.

Microbiological properties of groundwater: Seventeen groundwater supplies were examined by bacterial analysis to determine the suitability of water for drinking and other human purposes. The coliform bacteria (*E. coli*) naturally live in the colon and small intestine in human body by limited rates. It is important to performance of some vital functions such as oxidation of some vital materials and iron absorption. If their number is increased they will cause a risk for human life where lead to inflammation of the bowel wall and blood poisoning in worst cases in addition to the occurrence of diarrhea, fever, acidity in the blood and effect on kidney as well. Algae and bacteria that are living in water can survive in areas contaminated by sewage and other organic matter, so they usually used as indicator for pollution (Al-Tairah, 2004). *E. coli* is a bacterium used by Tegel as a microbial indicator due to it indicates diseases in chickens and humans and thus, it is an indicator of sewage pollution. In the region, the largest concern is bacterial pollution. As stated in the standards for water bacteria, the presence of coliform bacteria by 0-10 in each 100 cm^3 of water means the water is valid for drinking and an increase of bacteria ratios from 11-50 in each 100 cm^3 makes the water invalid for drinking while their increase from 51 and above in each cm^3 of water indicates that the water invalid for all human uses (Al-Tairah, 2004). Table 4 and 5 show that the most of water samples collected are not valid as drinking water because there was a bacterial growth and this is contrary to the Libyan standard specifications for drinking water and have effect on human health. Accordingly, it should remove the source of pollute and chlorination of water according to prescribed ratios for water treat. In general, there was an increase in the coliform bacteria ratios, the highest recorded coliform bacteria count was 30-35 with mix growth over count in the spring of Abu-Mansour and thus it is invalid for drinking and some of human uses.

Chemical properties of groundwater: Chemical analysis results have indicated to some variations between in the chemical properties of water. Evaluation of the results in Table 6 and 7 show the following:

- The ground water of the study area is equal to slightly alkaline as its pH varies from 6.8-8.1

Table 4: Bacterial analysis in wells

Well no	Coliform bacteria in 100 cm^3	Result
1	Undefined	Not valid for drinking
2	*E. coli* (8-10) Mix growth over count	Not valid for drinking
3	Mix growth over count	Not valid for drinking
4	*E. coli* (20-25) Mix growth over count	Not valid for drinking
5	*E. coli* (5-8) Mix growth over count	Not valid for drinking
6	*E. coli* (4-6) Mix growth over count	Not valid for drinking
7	*E. coli* (8-10) Mix growth over count	Not valid for drinking
8	Mix growth over count	Not valid for drinking
9	*E. coli* (not found) Mix growth (4-6)	Valid
10	Not found	Valid
11	*E. coli* (20-22) Mix growth (10-12)	Not valid for drinking
12	*E. coli* (24-27) Mix growth (80-85)	Not valid all uses
13	Not found	Valid
14	Not found	Valid
15	Not found	Valid

Table 5: Bacterial analysis in spring

Spring	Coliform bacteria (100 cm^3)	Result
Al-Bilad	*E. coli* (30-35) Mix growth (over count)	Not valid for drinking
Abu-Mansour	*E. coli* (20-25) Mix growth (over count)	Not valid for drinking

- The maximum value of EC was 12050 μS cm^{-1} in the well number 7 and the minimum was 780 μS cm^{-1} in Spring of Abu-Mansour, with a mean of 2630.417 μS cm^{-1} this is of course given to the increase of salts
- The T.D.S values in some wells have exceeded the permissible maximum limits with an average of 1889.923 mg L^{-1} and the maximum was 8000 mg L^{-1}. The high amount of T.D.S in ground water may be due to seawater intrusion and low water level resulting from an increase of withdrawal with lack of rain particularly in the summer season
- Five wells have high concentration of T.H and exceeded the allowed maximum limit where the highest value was 8000 mg L^{-1} in the well number 7
- As can be seen from the Table 4 the Ca^{++} concentration is within allowed limits except the well number 7 which was 280 mg L^{-1}
- Fe, NH_4 and NO_2 concentrations are found to be more than permissible limits for drinking water in well number 11 only
- Well number 7 also has a very high concentration of C1 which was 1140 mg L^{-1} and PO_4 was existent in three wells
- The springs are almost devoid of high chemical concentrations that exceed the standard of drinking water

The health impact of water pollution: The polluted water is considered the main reason of for the prevalence of some serious diseases to human. The health crisis in the city of Derna has been exacerbated due to high rates of drinking water contamination resulting from mixing with sewage and the high proportion of salt. Which put the population of the city on the brink of disaster; its features have been emerged during the recent period with the

Table 6: Chemical water quality parameters in wells

	Parameters										
Maximum limit	pH 6.5-9.2	EC ($\mu S\ cm^{-1}$)	T.D.S (500-1500 mg L^{-1})	T.H (100-500 mg L^{-1})	Ca^{++} (75-200 mg L^{-1})	Mg^{++} (50-150 mg L^{-1})	Fe (1.0 mg L^{-1})	NH_4 (0)	C1 (600 mg L^{-1})	NO_2 (0)	PO_4 (0)
Well no.1	7.4	2950	2183	750	160	92	0	0	260	0	0
Well no.2	7.8	2340	1684	640	112	87	0	0	240	0	Effect
Well no.3	7.0	1777	1200	560	136	53	0	0	160	0	0
Well no.4	6.8	3380	2028	900	186	116	0	0	360	0	0
Well no.5	7.0	1570	942	380	88	38	0	0	180	0	0
Well no.6	7.0	1638	982	400	64	58	0	0	140	0	0
Well no.7	-	12050	8000	1700	280	243	0	0	1140	-	-
Well no.8	-	-	4000	-	-	-	-	0	-	-	Existent
Well no.9	-	1300	750	340	56	32	0	0	80	-	0
Well no.10	7.3	790	640	320	64	64	0	0	160	0	0
Well no.11	7.7	1900	950	380	96	34	Effect	Over existent	180	Over existent	Existent

Table 7: Chemical water quality parameters springs

Parameters allowed limit	pH (6.5-9.2)	EC ($\mu S\ cm^{-1}$)	T.D.S (500-1500 mg L^{-1})	T.H (100-500 mg L^{-1})
Spring of Al-Bilad	7.0	1090	700	350
Spring of Abu-Mansour	8.1	780	510	240

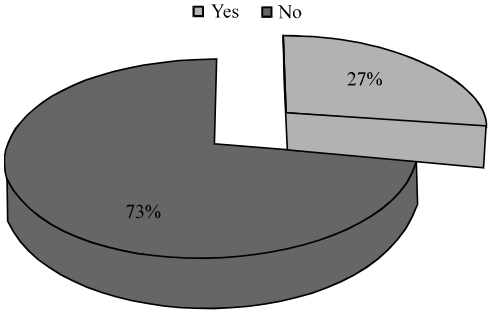

Fig. 6: The diseases that caused from water pollution

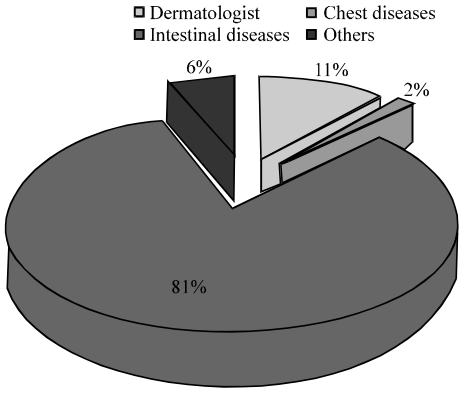

Fig. 7: Types of diseases

increasing of incidence of intestinal, dermatologist and chest diseases in additional to poisoning and cirrhosis of the liver and kidney failure where approximately 27% of residents in the region confirmed that some of their families members got diseases and most (81%) of these diseases are intestinal diseases as shown in Fig. 6 and 7.

CONCLUSION

This study aimed to analyze the groundwater contamination and the health impact resulting from overflowing and leaking of municipal wastewater Derna (North-East Libya). The study found that there was a change in the quality of groundwater caused by leaking of wastewater from dilapidated net work and septic tank to groundwater. The high proportion of bacteria and some of chemical element in the groundwater have affected on residents health. Thus, the study wish to recommend the following as measures that could be used to reduce the problem:

- Development of the former sewage treatment plant or create a new one
- Development of the sewerage network in the region and attempt to cancel the septic tanks to limit of sewage overflowing
- Chlorination of water constantly in order to remove the effects of pollution

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