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Pollution of water resources from industrial effluents: a case study — Benghazi, Libya

Abdulmonem Elhassadi

Department of Chemistry, University of Garyounis, P.O. Box 7900, Benghazi, Libya
Tel. +218 925562289; Fax +218 61 2230310; email: elhassadi2004@yahoo.com

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Abstract

Water shortage problem is considered to be one of the biggest problems facing the middle eastern region, specifically the Arab countries located in semi-arid zones. The natural water resources of the region are suffering from outside control dominated by complex political circumstances, and inside deteriorations imposed by the combination of a fast growing population, and the challenges of industrialization which increases the water demands for domestic, agricultural and industrial applications. This puts a high stress on the natural water resources and make them vulnerable to pollution.

This paper investigates the problem of pollution caused by industrial wastes, evaluates prevention means, and promotes desalination techniques.

Keywords: Pollution of water resources; Industrial effluents; Benghazi; Libya; Water shortage Problem (WSP)

1. Introduction

Water is considered to be the most import pillar of modern civilization in all aspect of life. The Arab world located in the Middle Eastern Region, is faced with acute challenges imposed by geographical, political, and developmental situations. The Arab world, being located in arid and semi-arid regions, is well known of poor natural water resources. Beside that, most of its water resources is either originate from foreign regions controlled by complex political situations, or in a state of conflict.

The Arab world is witnessing a huge development era aiming at improving the sociological and economical well being of the people. The paramount population growth experienced by the Arab world heralds the exacerbation of pollution problem with its negative implications, the depletion of the available water resources and it necessitates provision of alternative water resources.

Comprehensive developments demands providing water for domestic, agriculture and industrial progress. Domestic water needs is the

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least demanding in quality with a well dictated standards by health organizations.

Agricultural development requires provision of large amounts of water of specific standards to accomplish the pursued nutritional security. Industrialization is the most demanding of water in its quantity and quality.

The purpose of this paper is to present an ideal example of the domestic and industrial effluents of a city on the southern coast of the Mediterranean to check and activate concern on the following issues:

- Environmental impacts on the Mediterranean Sea
- Pollution impacts on this greet water resource for desalination
- Cooperative efforts of all the concerned countries and regional organizations such as Euromed for developing
  - Solutions to environmental and pollution problem,
  - Desalination and wastewater treatment projects,
  - Natural conservation and reservation of this important sea.

2. Field study

Since the city of Benghazi is the second largest city in Libya and capital of the Eastern region, with a population of almost 750,000 and is considered to be a semi-peninsula, where the Mediterranean sea surrounds it from almost three direction, three major analysis points were selected for study to cover the whole perimeter as follow:

- Starting from the east on the coast, the first source of effluent disposal is selected to be Benghazi North desalination plant, this represents an industrial effluent,
- Heading toward the west on the coast, the second source of effluent disposal is selected to be Benghazi city sewage effluent, this represents a domestic effluent,
- Ending in the west on the coast, the third source of effluent disposal is selected to be Garyounis University effluent, this represents an educational domestic effluent with 32,000 students, and was analyzed in two ways, before and after treatment to sea the influence of treatment.

2.1. Experimental analysis

First, the monthly average was determined from three measurements analyses in the beginning, middle, and end of the month. Second, the yearly average was determined from the measurements of the twelve month around the year, to be checked historically from time to time to check the transient behavior of the pollution phenomenon. This yearly average is calculated from thirty six analyses measurements to represent a statistical analysis sample ($n = 36$).

3. Study findings

3.1. Pollution phenomenon

The southern shores and beaches of the Mediterranean are faced with two major pollutions.

- Historical pollution of the industrialized countries, the Northern shores of the Mediterranean, which is naturally driven south due to wind directions. The material wastes of this pollution is visible alongside all the shores of North Africa, especially in vacant areas without periodic cleaning and is represented by tar and plastic leftover.
- Recent pollution of the concerned countries residing in these shores, which are faced with:
  - Need of desalination plants to cover their water requirement as a result of increase in population,
  - Need of wastewater plants to treat their sewage disposal as a result of the increase in activity of this population,
  - Need of wastewater plants to treat their industrial effluents as a result of their vast industrialization.

3.2. Results and discussion

Evaluation of the results in the Tables 1–4 exhibits the following pollution remarks:

- The hypothetical question raised is that: does these industrial effluents have dangerous impacts on the environment — the Mediterranean sea? or not?
- Fifteen physicochemical properties were selected for study, six of them were physical, and nine were chemical. Statistically, the numbers represent a convenient statistical sample ($n = 36$) to investigate the behavior of every property independently and its influence on the other properties to test the pollution phenomenon under study.

Let us look at the values in Tables 1–4 of each property studied:

(1) Temperature: Values indicate no thermal pollution and they are within international standards.
(2) Color and turbidity: The effluents are polluted with suspended solids which necessitate treatment of these water for reuse to be below 1 NTU.
(3) PH: The effluents are neutral and with approved standards
(4) Conductivity: The values of this property effluents are neutral and are within the standards, except the desalination plant source which rejects brine to the environment. This is a sign of chemical pollution hazardous to marine life.
(5) Nitrite, nitrate and ammonia: This is an indication of biological pollution, suitable for microorganisms utilizing nitrogen as nutrition.
(6) Chloride: The same as in 4. This high chloride could be utilized for chlorine, hypochlorite, etc. manufacture.
(7) Calcium magnesium and total hardness: The effluents are clearly polluted with these constituents especially the desalination plant source, in case of reuse, treatment is required to avoid scale problems.
(8) Dissolved oxygen: Values are very low but suitable for microorganism life.
(9) Sulfates: The effluents are polluted with this chemical anion.
(10) Organic matter: Values are very low but suitable microorganism growth and energy.
(11) Free chlorine: Samples and not polluted with hazardous chlorine compounds.

4. Conclusions

It is clearly manifested from this scientific data, the acuteness of the pollution problem caused by these studied effluent sources.

There might be other industrial effluent sources that dispose more hazardous pollution wastes than the studied sources.

Hence, it is recommended that:

- Surveillance and control of all industrial wastes to the environment and building of proper treatment plants to handle the miscellaneous pollution wastes.
- Creation of public awareness of the importance of protection of the environment from hazardous pollution by all informative means.
- Legislation of proper regulations and laws that serve protection of the environment in cooperation with Euromed countries and organizations.
- Establishment of environmental protection authorities that are capable of:
  - Developing public awareness,
  - Monitoring of pollution problems,
  - Providing consultation and expertise to pollution problems
- Protection of all natural resources, specifically water resources from hazardous pollution.

Table 1
Benghazi North desalination plant effluent [1–3]

No.	Monthly average	Temperature (35°C)	Color nil	Turbidity (NTU, 50)	pH (6–9)	Conductivity (μs/m)	NO_2^- (ppm, 50)	NO_3^- (ppm, 90)	NH_3 (ppm, 10)	Cl^- (ppm, 100)	Total hardness (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Dissolved oxygen (ppm)	SO_4^{2-} (ppm, 1200)	Organic matter (ppm, 100)	Free chlorine (5)
1	January	25	0.0	2	7.9	3.5×10^3	–	0.1	2.8	22,500	6300	1150	5150	20	–	5.3	0.0
2	February	25	0.0	0.0	8.5	5.8×10^3	No reagent	0.1	3.0	25,500	8100	1400	1400	–	19	3.8	0.0
3	March	24	0.0	0.0	8.0	6×10^4	–	0.1	2.5	26,500	7200	1800	5400	–	20	3.9	0.0
4	April	28	0.0	0.0	8.3	5.1×10^4	0.0	3.5	7.0	46,056	4680	1080	3600	2.30	800	–	0.0
5	May	26	0.0	0.0	9.4	5.2×10^4	0.0	2.5	7.0	44,540	12,000	2160	9840	0	800	–	0.0
6	June	27	0.0	0.0	8.2	5.1×10^4	0.0	3.5	3.0	55,650	13,240	2720	10,520	6.6	650	–	0.0
7	July	28	0.0	0.0	8.6	6.5×10^4	0.002	3.0	4	8240	1840	6400	–	–	750	–	0.0
8	August	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0
9	September	30	0.0	0	8.6	6.5×10^3	0.02	7.0	3.3	35,020	10,880	3360	7520	12	1200	–	0.0
10	October	–	0.0	0	8.4	7×10^4	–	1.0	2.5	15,000	3900	2300	3900	–	880	4.7	0.0
11	November	–	18	2	8.4	6.8×10^4	–	50	5.0	21,000	7600	1600	5900	4.0	1200	4.7	0.0
12	December	–	0.0	0.0	8.5	6.8×10^4	–	20	2.0	21,000	8000	1500	6500	17.3	1200	5.4	0.0
–	Yearly average values	22.6	0.0	0.0	8.4	4.8×10^4	0.01	8	4	24,259	7561	2168	5393	9.0	678	4.6	0.0

Table 2
Benghazi city sewage effluent [1–3]

No.	Monthly average	Temperature (35°C)	Color nil	Turbidity (NTU, 50)	pH (6–9)	Conductivity (μs/m)	NO_2^- (ppm, 50)	NO_3^- (ppm, 90)	NH_3 (ppm, 10)	Cl^- (ppm, 100)	Total hardness (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Dissolved oxygen (ppm)	SO_4^{2-} (ppm, 1200)	Organic matter (ppm, 100)	Free chlorine (5)
1	January	18	70	25	7.5	9×10^3	No reagent	0.8	7.2	3000	850	400	450	7.0	–	28	0.0
2	February	20	98	18	7.9	4×10^3	–	0.7	9.0	3750	700	200	200	–	7.5	2.2	0.0
3	March	19	120	20	7.7	6.6×10^3	–	0.7	8.0	2.6×10^3	1300	100	1200	–	8	2.7	0.0
4	April	23	50	5	7.6	8.7×10^3	4.0	–	1.1	2430	960	740	220	0.6	480	–	0.0
5	May	24	50	5	8.4	8.6×10^3	4.0	9	1.6	3000	1040	460	580	4.5	350	–	0.0
6	June	27	50	10	7.4	1.1×10^4	3.2	8.0	10	3670	1760	1200	560	0	430	–	0.0
7	July	25	60	10	7.7	8.5×10^3	3.2	–	12	2640	1200	1440	0.0	–	330	–	0.0
8	August	24	40	5	7.7	6.4×10^3	3.2	10	7.0	2120	2680	1040	1600	4.7	700	–	0.0
9	September	24	40	5	8.4	1.2×10^4	2.4	9.0	5.5	2900	2880	2640	240	2.0	520	–	0.0
10	October	–	120	18	8.2	8.5×10^3	–	5.0	9.0	1.5×10^3	3.2×10^3	–	3.2×10^3	5.4	500	4.7	0.0
11	November	–	140	24	8.0	2.5×10^4	–	45	10	2.1×10^3	2×10^3	7×10^2	1.3×10^3	0.0	450	3.0	0.0
12	December	–	150	10	7.8	1.9×10^4	–	25	10	2.2×10^3	1.4×10^3	5×10^2	9×10^3	2.5	250	5.4	0.0
–	Yearly average values	22.7	61	13	7.9	1.1×10^4	3.4	11	8	2684	1727	856	871	3.0	366	3.6	0.0

Table 3
Garyounis University effluent – before treatment [1 – 3]

No.	Monthly average	Temperature (35°C)	Color nil	Turbidity (NTU, 50)	pH (6–9)	Conductivity (μs/m)	NO_2^- (ppm, 50)	NO_3^- (ppm, 90)	NH_3 (ppm, 10)	Cl^- (ppm, 100)	Total hardness (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Dissolved oxygen (ppm)	SO_4^{2-} (ppm, 1200)	Organic matter (ppm, 100)	Free chlorine (5)
1	January	18	600	90	6.7	7×10^3	No reagent	1.8	36	3350	1400	480	920	0.0	–	5.3	0.0
2	February	18	310	150	7.5	8×10^3	–	1.9	14	5250	1400	200	200	–	0	2.5	0.0
3	March	19	350	60	7.5	8.9×10^3	–	2.0	15	$3 x 10^3$	1500	300	1200	–	0	2.3	0.0
4	April	23	350	50	7.4	1.2×10^4	0.08	10	24	3640	1400	700	700	0.0	110	–	0.0
5	May	23	300	60	7.6	1.2×10^3	0.06	20	8	2440	1380	540	840	0.0	170	–	0.0
6	June	27	280	50	6.8	1.2×10^4	0.06	3.0	24	2450	2560	1440	1120	0.0	260	–	0.0
7	July	22	250	50	6.95	1.2×10^3	0.06	13	18	3280	1440	184	0.0	–	360	–	0.0
8	August	25	350	60	7.0	1.2×10^4	0.05	25	20	2880	3200	1040	2160	0.0	300	–	0.0
9	September	26	270	50	7.2	1.1×10^4	0.07	25	20	2400	1600	880	720	0.0	400	–	0.0
10	October	–	270	45	7.5	1.2×10^3	–	12.5	40	2.9×10^3	2.75×10^3	1.6×10^3	1.35×10^3	0.0	280	3.8	0.0
11	November	–	600	100	7.2	2.3×10^4	–	60	40	3.1×10^3	1.7×10^3	5.0×10^2	1.2×10^3	0.0	370	3.8	0.0
12	December	–	440	68	7.1	2×10^4	–	50	50	3.1×10^3	1.9×10^3	2.5×10^2	1.65×10^3	0.0	190	3.5	0.0
–	Yearly average values	22	264	69	7.2	1.2×10^4	0.06	19	26	3149	1681	676	1008	0.0	222	3.5	0.0

Table 4
Garyounis University effluent — before treatment [1–3]

No.	Monthly average	Temperature (35°C)	Color nil	Turbidity (NTU, 50)	pH (6–9)	Conductivity (μs/m)	NO_2^- (ppm, 50)	NO_3^- (ppm, 90)	NH_3 (ppm, 10)	Cl^- (ppm, 100)	Total hardness (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Dissolved oxygen (ppm)	SO_4^{2-} (ppm, 1200)	Organic matter (ppm, 100)	Free chlorine (5)
1	January	14	425	80	7.3	1.4×10^4	No reagent	0.25	6.4	4500	1600	390	1210	0.0	–	2.8	0.0
2	February	18	270	55	8.7	2×10^4	–	0.2	4.5	6000	1900	200	200	–	0.0	3.8	0.0
3	March	19	350	60	7.5	8.2×10^3	–	0.2	5.0	2.6×10^3	1600	100	1500	–	0.0	3.5	0.0
4	April	22	220	40	8.5	1.2×10^4	0.2	5	0.4	4240	1160	700	460	9.7	560	–	0.0
5	May	23	100	15	9.2	1.2×10^4	0.5	6	2.0	5400	1600	660	940	10	500	–	0.0
6	June	25	60	10	9.2	1.4×10^4	0.06	7.0	3.5	3950	2480	1040	1440	19	420	–	0.0
7	July	24	600	120	9.2	1.2×10^4	0.06	10	3	3040	960	1080	3.2	–	420	–	0.0
8	August	27	320	55	9.3	1.2×10^4	0.04	6.0	1.9	2800	1288	1160	1200	34	450	–	0.0
9	September	27	80	10	9.4	1.2×10^4	0.05	6.0	1.6	3900	2240	2080	160	28	520	–	0.0
10	October	–	200	45	9.0	1.2×10^4	–	1.0	5.0	2.9×10^4	2.5×10^3	1.25×10^3	1.3×10^3	16.1	450	3.8	0.0
11	November	–	420	70	9.5	2.3×10^4	–	50	10	3.2×10^3	1.5×10^3	5×10^2	1×10^3	34	390	3.2	0.0
12	December	–	370	60	9.5	2.1×10^4	–	25	2.0	3.3×10^3	1.5×10^3	2.5×10^2	1.25×10^3	240	312	3.2	0.0
–	Yearly average values	22	285	52	8.9	2×10^4	0.15	10	4	3819	1756	868	888	19	331	3.4	0.0

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