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ASSESSMENT OF WATER QUALITY INDEX AT INDUSTRIAL ZONE, DAMIETTA

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ABSTRACT:

Water samples were collected from different locations in three steps; spinning, weaving and dyeing at DNM Textile Company. Analytical techniques as described in the standard methods for examination of water and waste water were adopted for physico-chemical analysis of water samples and the results compared with the standards given by **Egyptian (2015)** and **WHO (2004)** guidelines for drinking water. The average water quality index were 1654,1304 and 1462 for spinning, weaving and dyeing respectively

Keywords: *Textile industry, wastewater, water quality index*

الملخص

تهدف الدراسة الى رصد و تقدير اهم الخصائص الفزيائية و الكيميائية للمياه المستخدمة فى عمليات و مراحل صناعة الغزل و النسيج (الغزل، النسيج و الصباغة) بالمنطقة الصناعية-دمياط (شركة DNM). تمت عمليات التحاليل و القياس باستخدام و تطبيق كلا من المعايير القياسية المصرية و العالمية و ذلك طبقا لمنظمة الصحة العالمية (WHO، 2004) و المعايير المصرية طبقا لقانون رقم 27 لسنة 1978 (اصدار 2015) .

وضحت النتائج القيم المختلفة لمعايير جودة المياه و ذلك خلال المراحل المختلفة لصناعة الغزل و النسيج (الغزل، النسيج و الصباغة). كما اظهرت الحسابات القيم المرتفعة لمعامل جودة المياه (WQI) و التي تشير الى درجات مرتفعة من درجات التلوث البيئى بالمنطقة. كما أوصت الدراسة بضرورة الفحص الدوري و المستمر للمنطقة الصناعية و ذلك للحد من التلوث

INTRODUCTION

In the last three decades, the rapid growth of industrialization and urbanization has created negative impacts on the environment due to industrial, municipal and agriculture wastes containing pesticides, insecticides, fertilizers residues and heavy metals. Several industries are being establishes day by day due to meet the complex the requirement of rapid growing urbanization, consumerization and increase the demand of product in the modern time **(Sastry and Rathee, 1999).** Due to the industrial and economic growth and the production of a variety of compounds and chemicals followed by increased consumption man makes some unwanted pollutants, many of which cause serious problems and risks for the environment and for man himself (**Abd El Hamid *et al*., 2016**).

In modern industrialization period, the most of water resources have affected enormously by seepage, leaching and mixing of industrial effluents. The major source of surface and ground water pollution is injudicious discharge of untreated industrial effluents directly into the surface water bodies resulting in surface and ground water pollution **(Nasrullah *et al.*, 2006)**.

Water quality index (WQI) has provided an assessment of water quality trends for management purpose even though it is not meant especially as an absolute measure of the degree of pollution or the actual water quality **(HACH, 2012).** WQI is calculated from the point of view of the suitability of ground water for human consumption **(Ramakrishnaiah *et al.*, 2009). Dhanya *et al*. (2005)** have studied the impact of dyeing industrial products on the groundwater quality and soil microorganisms and found that the water samples had higher values of all the parameters except nitrate. Earlier studies by **Kesavan and Parameswari (2005)** revealed that the groundwater sources are not suitable for drinking purpose without proper treatment. The waste water without any treatment may cause adverse effect on the health of human, domestic animals, wildlife and environment. Contaminated ground water has deteriorated the drinking water and impacts on soil systems and crop productivity.

The present study aims to identify and assess the ground water contamination and quality problems in DNM Company along the three steps (spinning, weaving and dying) of this industry.

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MATERIALS AND METHODS

Study area

DNM Textile Company was incorporated in 2011 in city of Damietta, Egypt with 100% Turkish capital **(DNM Annual Report, 2011)**. DNM is a vertically integrated denim fabric production plant constructed at the public free zone on an outdoor area of 150,000 square meters with an indoor area of 130,000 square meters fitted with the state-of-the-art technological machinery **(DNM Annual Report, 2011)**. DNM produces 50 tons of yarn on daily basis with the total annual production capacity of 25 million meters. The annual production capacity of the plant aimed after completion of the 2nd phase in the forthcoming term will be 50 million meters **(DNM Annual Report, 2011)**.

Sample analysis

Ground water samples were collected from three locations at DNM textile company (Fig. 1). The sampling from spinning, weaving and dyeing were selected as an indicator of textile industry. The water samples were collected during the daytime. Samples were collected in one liter plastic bottles. Before sampling, the plastic bottles were cleaned thoroughly to remove all surface contamination, rinsed with double distilled water and dried. The collected samples were properly brought to the laboratory without adding any preservative. Suspended matters if any, in the samples, were removed by filtering through Whatmann` filter No.41. Then it is stored in the refrigerator at 40°C till the analysis was over.

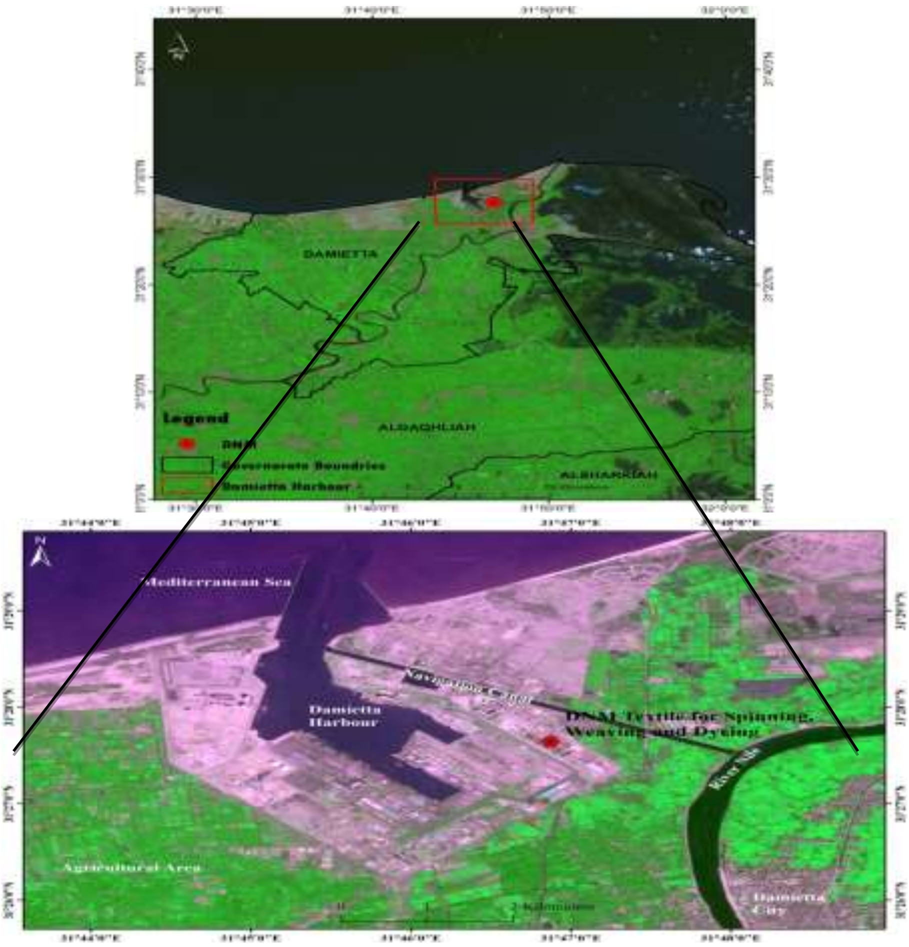

Figure (1): Location map of the study area

The samples were analyzed for major physical and chemical water quality parameters like pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), sulfide (H_2S), Na^+, Cl^- and SO_4^{2-}. Dissolved oxygen (DO) was determined by the modified Winkler method. Biological oxygen demand (BOD), Chemical oxygen demand (COD), oil and grease, total o- phosphorus, nitrate–N, nitrate-N, and ammonia-N. All parameters were determined according to **APHA (2012).**

Water quality index (WQI) is a tool to determine the quality of water **Brown *et al*. (I970).** It is a well-known method of expressing water quality that offers a stable and reproducible unit of measure which responds to changes in the principal characteristics of water. WQI is a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality. WQI is calculated by using the weighted arithmetic index method. By this method, different water quality components are multiplied by a weighting factor and are then aggregated using simple arithmetic mean.

In this study, for assessing the quality of water, the quality rating scale (q_i) for each parameter was calculated by using the following equation:

$$q_i = 100\,[V_i / S_i] \qquad \mathbf{(1)}$$

where V_i = observed value of the parameter at a given sampling site and Si = stream water quality standard. Equation (**1**) ensures that q_i = 100 if the observed value is just equal to its standard value. Thus, the larger value of q_i the more polluted the water. Then, after calculating the quality rating scale (qi), the Relative (unit) weight (W_i) is calculated by a value inversely proportional to the recommended standard (S_i) for the corresponding parameter using the following expression; W_i = K/Sn Where, K [constant] = $1/[(1/S_1) + (1/S_2) + (1/S_3)+ \ldots.. + (1/S_n)]$ Here, W_i = Relative (unit) weight for nth parameter Sn = Standard permissible value for nth parameter. Finally, the overall WQI is calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

$$WQI = \Sigma n_{i=1} (Q_i W_i) / \Sigma\, n_{i=1} W_i \qquad (\mathbf{2})$$

Table (1): Water quality classification based on WQI value.

WQI value	**Class**	**Water quality**
<50	I	Excellent
50-100	II	Good
100-200	III	Poor
200-300	IV	Very poor
>300	V	Unsuitable water

RESULTS AND DISCUSSION

The results of physico-chemical characteristics of ground water are presented in Table (**2**). It was observed that there is no change in pH values in the three steps. The values of total dissolved solids were 83444-80087 and 79512 mg/l during spinning, weaving and dying respectively. These results are supported by the recent work of **Khan and Noor (2012).** Highest values of TDS were recorded showed inferior potable quality and induced an unfavorable physiological reaction in the temporary consumer and gastrointestinal infections. TDS value was decreased during dying process.

Electrical conductivity with regards to water quality referred to the amount of salts in the water and is a numerical expression of the ability of an aqueous solution to convey an electric current. It is also an approximate indicator of total dissolved ions such as heavy metals and widely used for pollution monitoring **(Nasrullah, *et al.* 2006).** The values of conductivity of water of bore well and hand pumps ranged from were 108800-107500 and 107300 μmho/cm during spinning, weaving and dying respectively.

Dissolved oxygen in ground water samples were recorded in the range 2.7, 4.1 and 3.4mg/l l during spinning, weaving and dying respectively. The lower value of DO (2.7) at during spinning may be due to the lowest distance from the outgoing industrial drain which indicates organic pollution in water due to percolation of effluent containing soluble organic compounds. Values of dissolved oxygen recorded in the spinning step under the permissible limit 3.0-14.0 mg/l given by **WHO (2004)**. Biochemical oxygen demand (BOD) is inter-related with the levels of dissolved oxygen in the water. Organic comp such as carbohydrates, proteins and fats, which can be a result of urban run-off, domestic sewage and industrial effluent are broken down by the microorganisms present in the water and exerted an oxygen demand in aquatic system **(Efe, *et***

***al.*, 2005).** BOD values in water were recorded in the range 2343, 1230 and 1922 during spinning, weaving and dying respectively.

However, COD values represent the amount of required for microbial decomposition of organic matter. Amount of oxygen required for chemical decomposition of organic matter were recorded in the range 4761, 4080 and 4100-mg/l during spinning, weaving and dying, respectively. All the values of COD recorded high comparison than standard value (10 mg/l) given by **WHO (2004)**. The dissolved oxygen, BOD and COD have not favored the permissible value of drinking water quality, which existed in ground water of villages located near to industrial area. Hence, the existed drinking water has been contaminated by the leaching industrial effluents and intermixing with ground water table.

Chloride values of ground water were in the range 50159, 48932 and 489363 mg/l in during spinning, weaving and dying, respectively. Excessive chloride imparts bitter taste to water and corrode steel and may cause cardio-vascular problem. Nitrate values in ground water samples were2.9, 4.7 and 22.9 during spinning, weaving and dying respectively. Water with more than 45 mg/l of nitrate is not permissible for drinking as per **WHO (2004)** and limit is mandatory. Beyond this, it may cause metheamoglobinemia or blue baby syndrome in infants. It may also be carcinogenic in adults (**Basappa, 2003**). Nitrite values in ground water samples were 0.1, 0.07 and 0.07 mg/l in during spinning, weaving and dying respectively. All the values of nitrite come under the standard value given by **WHO (2004)**.

Average water quality index calculated on the basis of existed seasonal physico-chemical characteristics of ground water in all sampling sites. AWQI ratings were in the range 1654, 1304 and 1462 during spinning, weaving and dying, respectively. The present investigation revealed that the water quality along the three steps: spinning, weaving and dyeing were high degraded due to high range of average water quality index. The values were 1654,1304 and 1462 for spinning, weaving and dyeing respectively. Water quality is frequently threatened or impaired and conditions usually depart from natural or desirable levels. The present WQI clearly indicated that ground water quality is slightly critical. The overall observation of present study indicated deterioration trend of ground water quality in the available water table on sampling areas due to lack of waste water treatment facilities in all industries. The ground water resources must be non-contaminated, purified and treated efficiently on sustainable basis at point and non-point sources of pollution level.

The drinking water quality should be properly maintained and be available for human society to get healthy longer life. Correlation analysis was carried out using Pearson's correlation coefficient. The correlation matrix was calculated for the water quality parameters, and is displayed in Table (5). Results of the correlation coefficient (r) were evaluated as follow: 0.0 (no); 0.3-0.5 (low); 0.5-0.7 (medium); 0.7-0.9 (high); 0.9-1(very high). In the present study, there were high significant correlations between many parameters. On the other hand, some parameters were correlated negatively (r = -0.99). Correlations were attributed to similar properties of the source of different parameters.

CONCLUSION

Water samples were collected from DNM Company were investigated according to the standards given by **Egyptian (2015)** and **WHO (2004)** guidelines for drinking water. Water quality index was calculated for quality standard of ground water for drinking purposes. The represented results revealed that the water quality of the above three steps were high degraded.

The average water quality index were 1654,1304 and 1462 for spinning, weaving and dyeing respectively. Water quality is frequently threatened or impaired and conditions usually depart from natural or desirable levels.

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Table (2): Water quality parameters of different steps in textile industry

Parameters	Unit	Spinning	Weaving	Dyeing
pH	-	7.6	7.6	7.6
TDS	mg/L	83444	80087	79512
EC	µS/cm	108800	107500	107300
Turbidity	NTU	3.2	3.1	2.6
DO	mg/L	2.7	4.1	3.4
NH_3	mg/L	0.6	1.4	2.2
NO_2^-	mg/L	0.1	0.07	0.07
NO_3^-	mg/L	2.9	4.7	22.9
o- Phosphorus	mg/L	0.03	0.02	0.03
BOD	mg/L	2343	1230	1922
COD	mg/L	4761	4080	4100
Oil and Grease	mg/L	336	190	154
H_2S	mg/L	2.3	6.6	3.4
SO_4^{-2}	mg/L	1949	822	786
Cl^-	mg/L	50159	48932	48936
Na^+	mg/L	29500	28300	28340

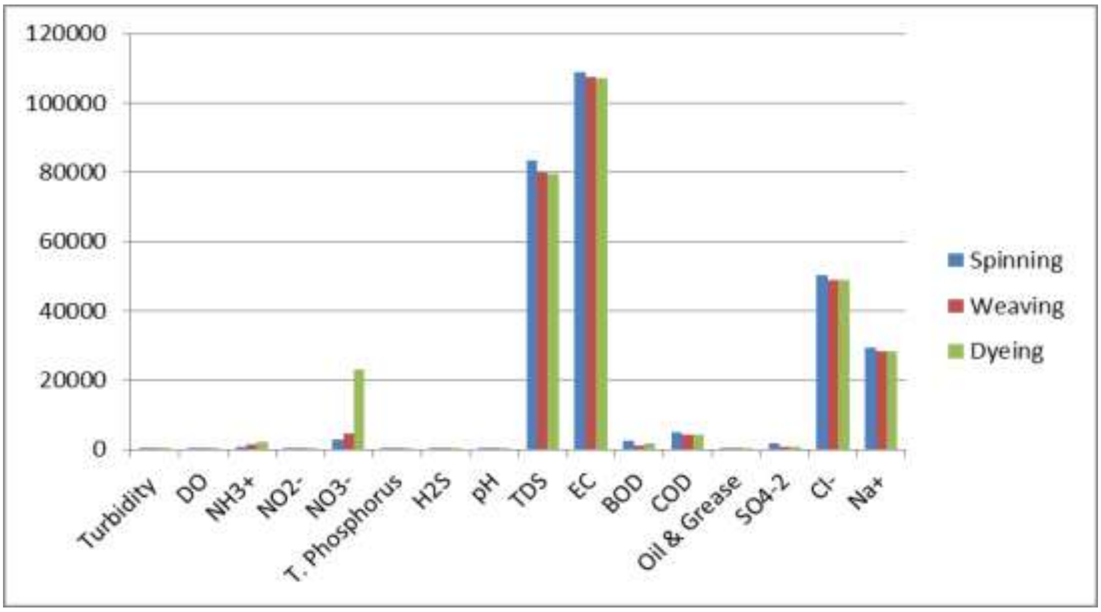

Figure (2): Physicochemical parameters of different steps of textile industry.

Table (3): Relative weight for each parameter (**Ramakrishnalah *et al.*, 2009**).

Parameters	**S_i**	**W_i**	**Relative W_i**
pH	8.5	4	0.0975
TDS	500	3	0.073
EC	2500	3	0.073
DO	5	2	0.048
NH_3	0.2	3	0.073
NO_2^-	3	3	0.073
NO_3^-	45	5	0.121
SO_4^{-2}	200	4	0.097
Cl^-	250	4	0.0975
Na^+	200	2	0.048
COD	10	4	0.097
BOD	6	4	0.097
Total	-	41	1

Table (4): WQI and AWQI of the study area

Parameters	Spinning		Weaving			Dyeing
	V_i	q_i =100[Vi/ Si]	V_i	q_i =100[Vi/ Si]	V_i	q_i =100[Vi/ Si]
pH	7.6	116.9	7.6	116.9	7.6	116.9
DO	2.7	54	4.1	82	3.4	68
NH_3	0.6	300	1.4	700	2.2	1100
NO_2^-	0.1	3.3	0.07	2.33	0.07	2.33
NO_3^-	2.9	6.4	4.7	10.44	22.9	50.88
SO_4^{-2}	1949	779.6	822	328.8	786	314.4
TDS	83444	16688.8	80087	16017.4	79512	15902.4
EC	108800	4352	107500	4300	107300	4292
Cl^-	50159	20063.6	48932	19572.8	48936	19574.4
COD	4761	47610	4080	40800	4100	41000
BOD	2343	39050	1230	20500	1922	32033.3
Total	-	129024	-	102430	-	114454
WQI = $\Sigma\ w_i q_i / \Sigma\ w_i$ i=1	-	18203	-	14354	-	16092
AWQI = Σ WQI /n	-	1654	-	1304	-	1462

Parameters	TDS	EC	Turbidity	DO	NH_3	NO_2^-	NO_3^-	o-P	BOD	COD	Oil and Grease	H_2S	SO_4^{-2}	Cl^-	Na^+
TDS	1														
EC	1.000**	1													
Turbidity	0.728	0.719	1												
DO	-0.790	-0.798	-0.156	1											
NH_3	-0.926	-0.921	-0.933	0.5	1										
NO_2^-	0.991	0.992	0.629	-0.866	-0.866	1									
NO_3^-	-0.675	-0.665	-0.997*	0.081	0.904	-0.569	1								
o-P	0.378	0.390	-0.359	-0.866	0.000	0.5	0.428	1							
BOD	0.697	0.706	0. 17	-0.990	-0.375	0.788	0.058	0.927	1						
COD	0.987	0.989	0.608	-0.879	-0.853	1.000*	-0.547	0.522	0.804	1					
Oil and Grease	0.999*	0.998*	0.763	-0.757	-0.944	0.982	-0.712	0.329	0.659	0.977	1				
H_2S	-0.594	-0.605	0.118	0.962	0.246	-0.698	-0.192	-0.969	-0.991	-0.716	-0.552	1			
SO_4^{-2}	0.994	0.995	0.650	-0.852	-0.879	1.000*	-0.591	0.476	0.771	0.999*	0.987	-0.678	1		
Cl^-	0.990	0.992	0.626	-0.867	-0.865	1.000**	-0.566	0.502	0.790	1.000*	0.982	-0.7	1.000*	1	
Na^+	0.986	0.988	0.606	-0.880	-0.851	1.000*	-0.544	0.525	0.806	1.000**	0.977	-0.719	0.998*	1.000*	1

Table (5): Correlation matrix of physicochemical param

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