Journal of Environmental Science and Engineering A 2 (2013) 1-14
Formerly part of Journal of Environmental Science and Engineering, ISSN 1934-8932

Seasonal and Spatial Variation in the Monitoring Parameters of Zomar Stream, Palestine during 2010

Saleh Sulaiman[1, 2], Laura Scrano[3], Sabino Aurelio Bufo[1] and Rafik Karaman[4]

1. Department of Science, University of Basilicata, Potenza 85100, Italy

2. Institute of Environmental and Water Studies, Birzeit University, West Bank, Palestine

3. Department of European Culture, University of Basilicata, Potenza 85100, Italy

4. Department of Bioorganic Chemistry, Faculty of Pharmacy, Al-Quds University, Jerusalem 20002, Palestine

Received: November 30, 2012 / Accepted: December 15, 2012 / Published: January 20, 2013.

Abstract: Levels of pollutants at Zomar stream, the only recreational area for the inhabitants of the northern part of the West Bank, Palestine, were recently determined, and have shown to be relatively high. Three bathing sites along the Zomar stream area were monitored for one year (fortnightly). Wastewater samples were subjected to microbiological analysis (fecal coliforms, *Escherichia coli*, *Pseudomonas*, *Enterococcus* and *Klebsiella*), physico-chemical analyses (water temperature, pH, electroconductivity and DO (dissolved oxygen)), biochemical oxygen demand, total Kjeldahl nitrogen and ammonia. The study results demonstrated seasonal and locational variations in all parameters studied. The highest levels of pollution were detected during summer, especially before a rainfall or after a discharge from onsite cesspits. Locations associated with sewage discharge were found to have the highest fecal indicator levels.

Key words: Wastewater pollution, seasonal variations, Zomar stream, microbiological contamination, BOD (biochemical oxygen demand).

1. Introduction

Zomar stream is exposed to major pollution by human activities causing serious health problems and high economic costs related to water treatment such as remediation and spotting new water supplies [1]. The Zomar stream is used as sewage drainage from the towns of Nablus, Tulkarem and villages located on the banks of the stream [2].

Point pollution sources along the stream are numerous; the major pollution sources are effluents that enter the stream through Wadi Zomar. Beginning with deposition of sewage from the western side of Nablus, the stream receives about 70 pollution sources along its pathway. These include sewage and effluents from refugee camps, towns, Tulkarem city, stone-cutting industries, landfills, leather factories, etc. [2].

Corresponding author: Saleh Sulaiman, Ph.D., main research field: wastewater. E-mail: ssssuliaman@gmail.com.

For three months every year, during the period October to December, waste from surrounding olive oil factories is added to the pollution load discharged spelt into the stream. According to one estimate, a total quantity of 2.5-3 × 10^6 m^3 per year of water transported by Palestinian territories effluents enter the green line (the border between Israel and the Palestinian territories) and this quantity is constantly rising [3]. The average temperature ranges between 8 °C to 14 °C in winter and 21.9 °C to 40 °C in summer; the average relative humidity varies from 39% in May to 84% in January [4].

In this study, we attempted to assess the microbiological and chemical quality of water along Zomar stream for a period of one year. Therefore, it is expected that the study results will assist local authorities in developing plans and policies aiming at implementing actions for the reduction of pollution to

acceptable levels. The study may prove to be helpful in setting standards and guidelines. In addition, the findings of the relationship between seasonal conditions and pollutant levels might be helpful in avoiding future harms to the environment.

2. Materials and Methods

2.1 Sampling Site Selection and Identification

A total of three sampling locations were selected for the assessment of flowing water. Site description, identification and GPS (global positioning system) data are reported in Table 1.

2.2 Sample Collection

Sampling was done according to the American Public Health Association [5].

2.3 Physiochemical Analysis

2.3.1 pH, Temperature, DO (Dissolved Oxygen), Turbidity and EC (Electrical Conductivity)

A field pH meter (Hanna, HI 1280) was used to measure both pH and temperature. Samples were stirred gently and stable readings were recorded [6]. DO was measured on site using a DO meter (Jenway 9070). Electrical conductivity was recorded using a calibrated EC meter (Jenway, 4310). The turbidometer (HACH, 2100 A) was calibrated using 2 and 20 NTU (nephelometric turbidity unit) standards. The sample was gently shaken, and a cuvette was filled in and recapped. The cuvette was placed in the suitable position and the light shield was replaced. The most stable value was recorded.

2.3.2 BOD (Biochemical Oxygen Demand)

For BOD_5 measurements the sample was transferred to an OxiTop (WTW) bottle, in which a magnetic stirring rod was placed. The rubber quiver was placed in the neck of the bottle to which two sodium hydroxide tablets were added. Measurements were made according to the manufacturer's instructions.

2.3.3 TKN (Total Kjeldahl Nitrogen) and Ammonia

TKN and ammonia were measured according to the Standard Methods for the Examination of Water and Wastewater [5].

2.3.4 Orthophosphate

A bunch of 0.45-mm membrane filters were soaked in 2 L of distilled water to remove any phosphorus residue. A drop of phenolphthalein indicator was added to 50 mL filtered sample. Activated carbon was used to remove any solution color. 35 mL of a sample were placed in a 50 mL volumetric flask containing 10 mL of vandate-molybdate reagent and diluted to the mark with distilled water. The absorbance was recorded after 10 min at 490 nm, and the concentration was calculated from a calibration curve [7].

2.4 Microbiological Analysis

2.4.1 Fecal Coliforms

A 0.45-mm Millipore sterile membrane was placed on a filter support assembly. The funnel portion was placed and fitted. The sample or sample dilution was shaken for about 30 times, the required volume was poured into a funnel, and light vacuum was applied to assess a rapid filtration. The membrane filter was aseptically removed and placed in the center of a Pre labeled mFC culture plate, which was then sealed and incubated in a water-bath incubator at 44.5 ± 1 °C. After 24-h incubation the blue colored colonies were

Table 1 Sampling and site identification.

Location No.	Sampling sites	Permanent mark	GPS location		
			North	East	Elevation (m)
1	Deir Sharaf	Dam	32°15′38.21″	35°10′29.29″	285.9
2	Anbta	Eman School	32°18′16.95″	35°07′07.25″	162
3	Tulkarem	Dam	32°19′25.79″	35°01′14.26″	55.3

Table 2 Pathogen types, presence and concentration in all sampling locations.

Sampling site	Sampling type	Pathogen type	cfu/100 mL found in each sampling date (2010)			
			January 31	February 15	February 21	March 2
Deir Sharaf	Sediment	*Escherichia coli*	4.8×10^5	4.8×10^7	1.4×10^7	2.7×10^5
		Pseudomonas	1.7×10^5	1.0×10^8	1.2×10^7	3.0×10^6
		Enterococcus	1.8×10^4	2.4×10^7	1.9×10^7	4.2×10^5
		Klebsiella	3.9×10^5	5.2×10^7	2.2×10^6	3.3×10^7
	Settled	*Escherichia coli*	2.7×10^5	2.3×10^5	4.9×10^4	3.3×10^4
		Pseudomonas	2.0×10^6	7.7×10^6	1.5×10^5	1.4×10^4
		Enterococcus	5.3×10^4	9.8×10^4	3.7×10^4	1.2×10^5
		Klebsiella	3.0×10^6	5.0×10^5	4.2×10^5	2.0×10^5
	Running	*Escherichia coli*	1.2×10^6	4.8×10^5	1.8×10^4	3.6×10^4
		Pseudomonas	3.2×10^6	1.8×10^6	7.2×10^4	2.5×10^5
		Enterococcus	9.9×10^4	1.0×10^5	3.0×10^4	1.4×10^5
		Klebsiella	2.8×10^5	2.8×10^6	1.1×10^5	5.5×10^6
Anbta	Sediment	*Escherichia coli*	2.0×10^5	8.8×10^6	1.4×10^5	1.1×10^4
		Pseudomonas	1.4×10^5	5.3×10^7	9.0×10^4	3.0×10^6
		Enterococcus	1.3×10^5	1.6×10^4	8.2×10^4	2.5×10^3
		Klebsiella	2.7×10^7	4.5×10^5	6.0×10^5	2.5×10^7
	Settled	*Escherichia coli*	1.4×10^6	2.4×10^5	5.0×10^3	120
		Pseudomonas	1.0×10^5	4.7×10^5	7.2×10^4	1.2×10^4
		Enterococcus	2.2×10^5	1.1×10^4	2.9×10^3	370
		Klebsiella	1.1×10^6	3.6×10^5	3.8×10^4	7.9×10^3
	Running	*Escherichia coli*	1.9×10^5	1.5×10^5	1.7×10^5	9.4×10^3
		Pseudomonas	2.5×10^5	3.0×10^5	1.0×10^5	7.8×10^4
		Enterococcus	1.1×10^4	1.2×10^5	1.3×10^5	1.7×10^4
		Klebsiella	1.9×10^5	3.4×10^5	5.5×10^4	8.0×10^4
Tulkarem	Sediment	*Escherichia coli*	2.0×10^5	8.8×10^6	1.4×10^5	1.1×10^4
		Pseudomonas	1.4×10^5	5.3×10^7	9.0×10^4	3.0×10^6
		Enterococcus	1.3×10^5	1.6×10^4	8.2×10^4	2.5×10^3
		Klebsiella	2.7×10^7	4.5×10^5	6.0×10^5	2.5×10^7
	Settled	*Escherichia coli*	1.4×10^6	2.4×10^5	5.0×10^3	120
		Pseudomonas	1.0×10^7	4.7×10^5	7.2×10^4	1.2×10^4
		Enterococcus	2.2×10^5	1.1×10^4	2.9×10^3	370
		Klebsiella	1.1×10^6	3.6×10^5	3.8×10^4	7.9×10^3
	Running	*Escherichia coli*	1.9×10^5	1.5×10^5	1.7×10^5	9.4×10^3
		Pseudomonas	2.5×10^5	3.0×10^5	1.0×10^5	7.8×10^4
		Enterococcus	1.1×10^4	1.2×10^5	1.3×10^5	1.7×10^4
		Klebsiella	1.9×10^5	3.4×10^5	5.5×10^4	8.0×10^4

counted [8]. Three to five colonies from each plate were picked and biochemical tests were performed to confirm the identity of the bacteria [9].

2.4.2 Pathogens

Specific enteric pathogens *E. coli*, *Enterococcus*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa* were isolated and measured as shown in Table 2. These pathogens were chosen based on their availability in the literature, ability to cause waterborne disease, presence in surface water and availability of technical capacity in Palestine. Pathogens were measured according to the Standard Methods for the Examination of Water and Wastewater [5].

3. Results

3.1 Temperature

Wastewater temperature differs slightly by location of sampling sites, ranging from 17 °C to 22.7 °C. This variation may be due to the quantity of sewage inputs and runoff. Results showed that DO and EC values increase with temperature increasing in most and in all locations, respectively (Fig. 1).

3.2 Variation of pH Values

Most pH measurements were found to be in an acceptable range, 7.5-8.5 [2] for all locations during the whole monitoring period, except for winter season where a slight increase in pH was observed. This might be related to a drop in electrical conductivity as indicated by the strong overlapping of pH and EC data (Fig. 2).

3.3 EC

Electrical conductivity measurements did not show any spatial and temporal variation. EC was strongly related to temperature, pH and fecal streptococci at all sampling sites. From Fig. 3, it can be seen that locations 1 and 3 exhibited a similar pattern during the monitoring period. Lower values were obtained during the rainy season; these values started to rise at the end of the season.

3.4 Turbidity

There was considerable variation in turbidity between the different locations. Moreover, turbidity was higher in winter than in summer. Location 1 showed the highest turbidity during the most sampling period, which might be attributed to a large amount of raw sewage inputs and subsequent algal growth and its closeness to the main source, as well. Turbidity was positively related to BOD, DO, ammonia, TKN, and both fecal coliforms and fecal streptococci. The only exception was found in the sampling location No. 1 because of its closeness to a pollution source caused by domestic and industrial activities (Fig. 4).

Generally, the relatively high susceptible point for anthropogenic activity was found near location 1 in the upper part, and the low susceptible point values were found near location 2, which is characterized by the lowest human activities (Fig. 4).

3.5 DO

DO dropped to alarming levels at almost all

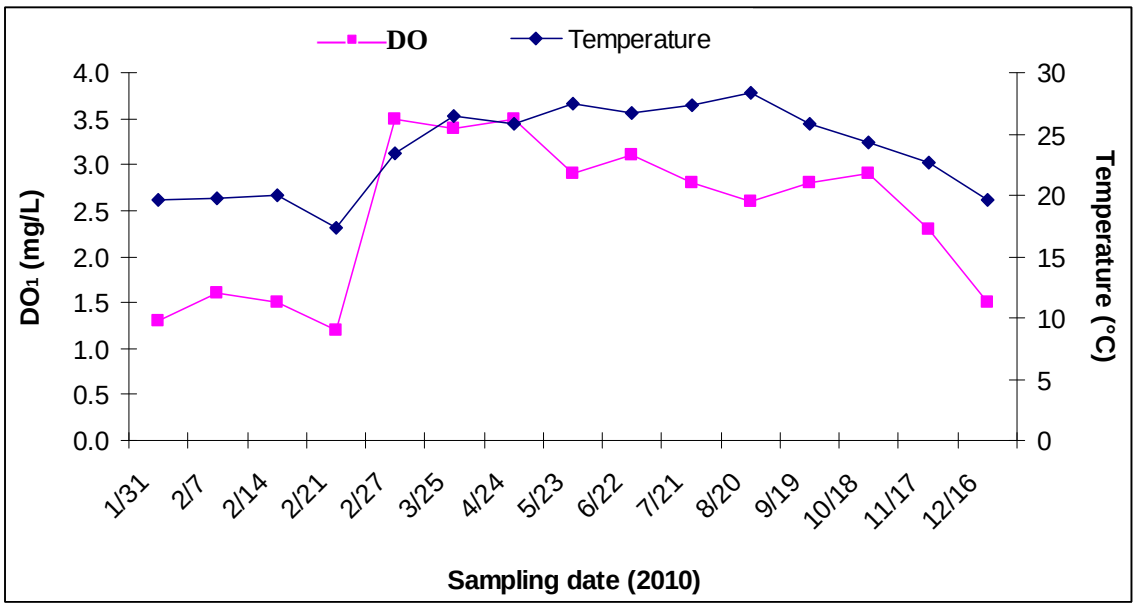

Fig. 1 Temperature and dissolved oxygen levels in the sampling site No. 1.

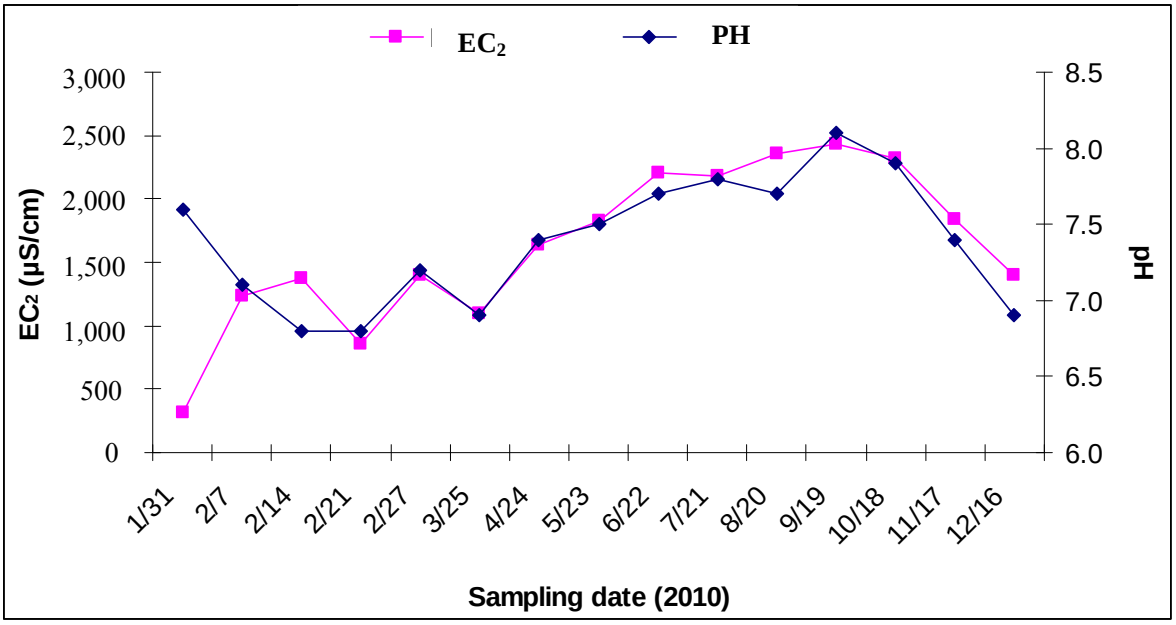

Fig. 2 pH and electrical conductivity levels in the sampling site No. 2.

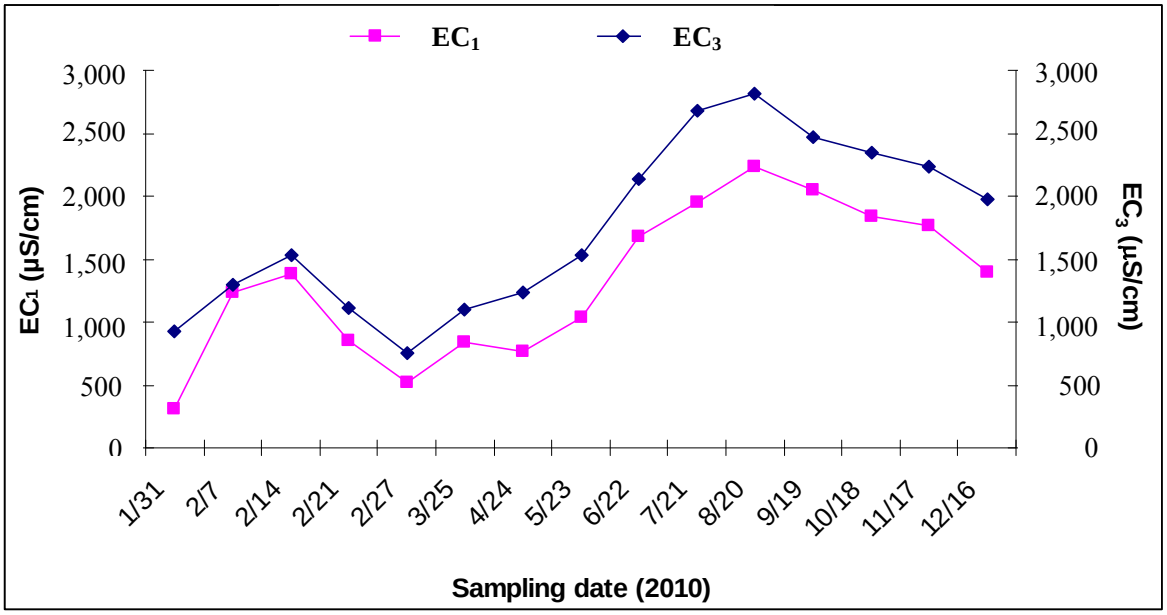

Fig. 3 Electrical conductivity levels in the sampling sites No. 1 and No. 3.

locations during certain collection periods. The average of measurements did not considerably vary, however, it was evident that DO was inversely related to BOD as shown in Fig. 5, which illustrates the seasonal variation in both DO and BOD at location 1.

3.6 BOD

There is a sharp difference in BOD levels among all locations studied. This difference may be related to the diverse distance and direction of sampling sites from sewage discharge points. The lowest average of BOD values were measured at location 2. This site is characterized by minimal organic matter pollution. Locations 1 and 3 showed the highest BOD levels. Location 1, which is heavily contaminated by sewage, was selected to illustrate the relationship between

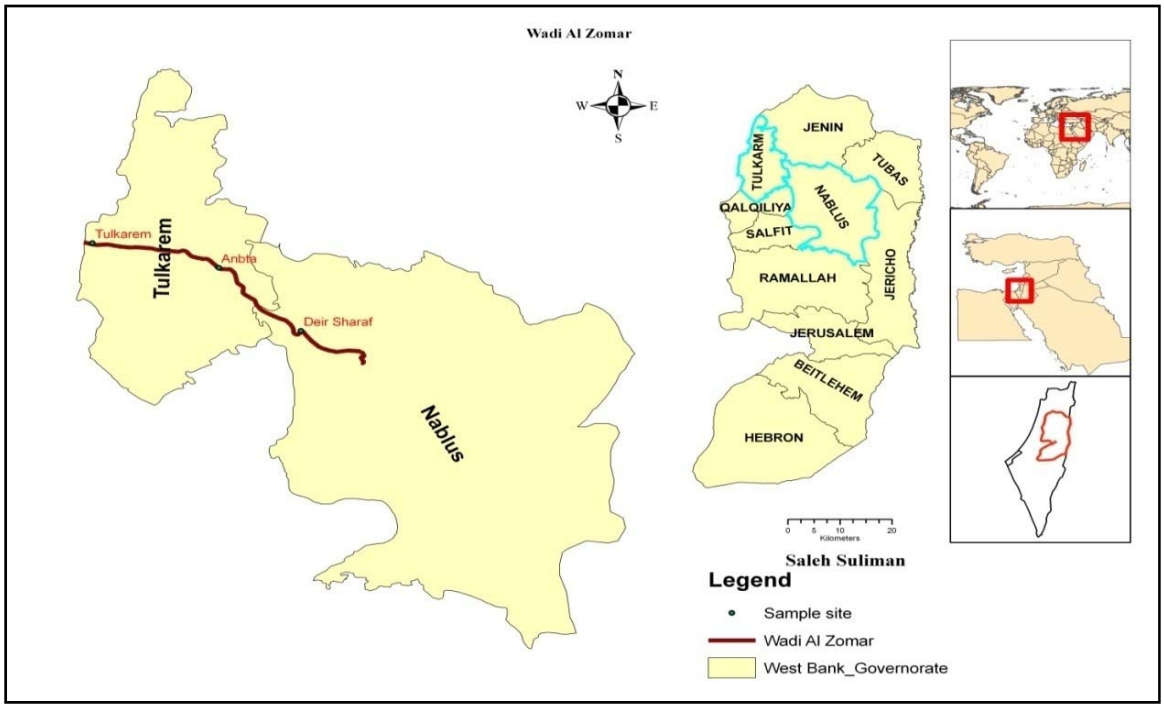

Fig. 4 Study area and sampling sites.

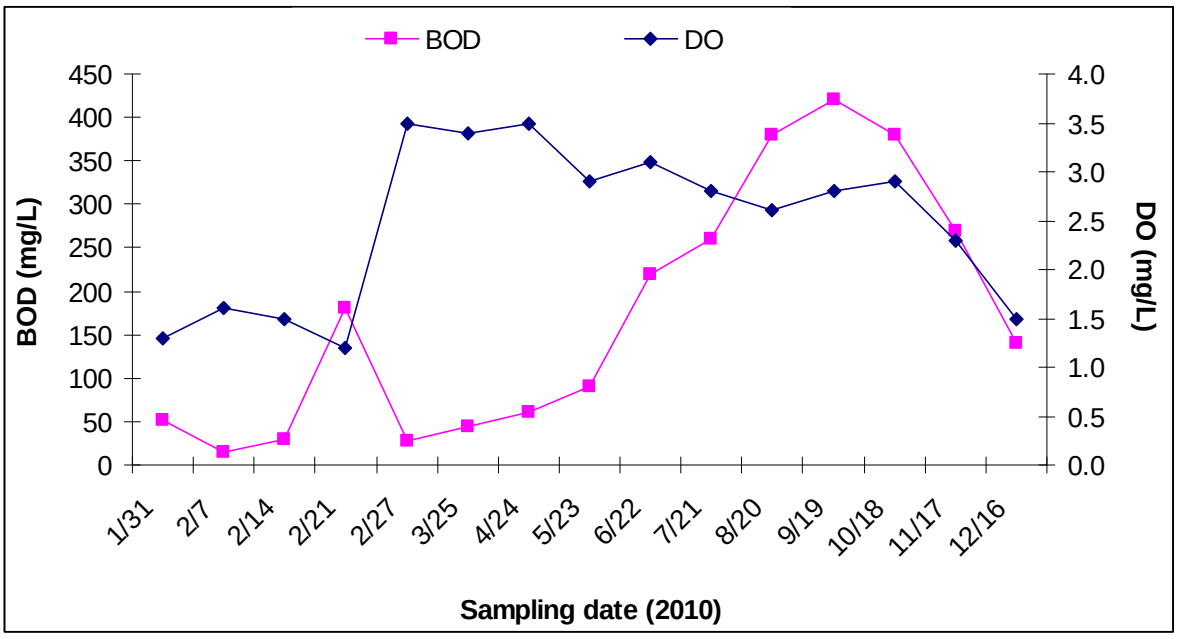

Fig. 5 BOD and DO progresses in the sampling site No. 1 during the monitoring time.

BOD and fecal indicators. From Fig. 6, it is evident that a high BOD value is almost associated with high FC (fecal coliforms) and fecal *Streptococcus* counts and vice versa.

The lowest BOD value was measured at location 2. The lower values of BOD might be due to a huge storm occurred at the end of February; this can be referred to a high potential of self purification where no other contaminants occurred. In contrast, location 1 showed high BOD levels, despite to a good discharge. As a result, the organic pollutant inputs to the various locations is not consistent, as it is evident from the

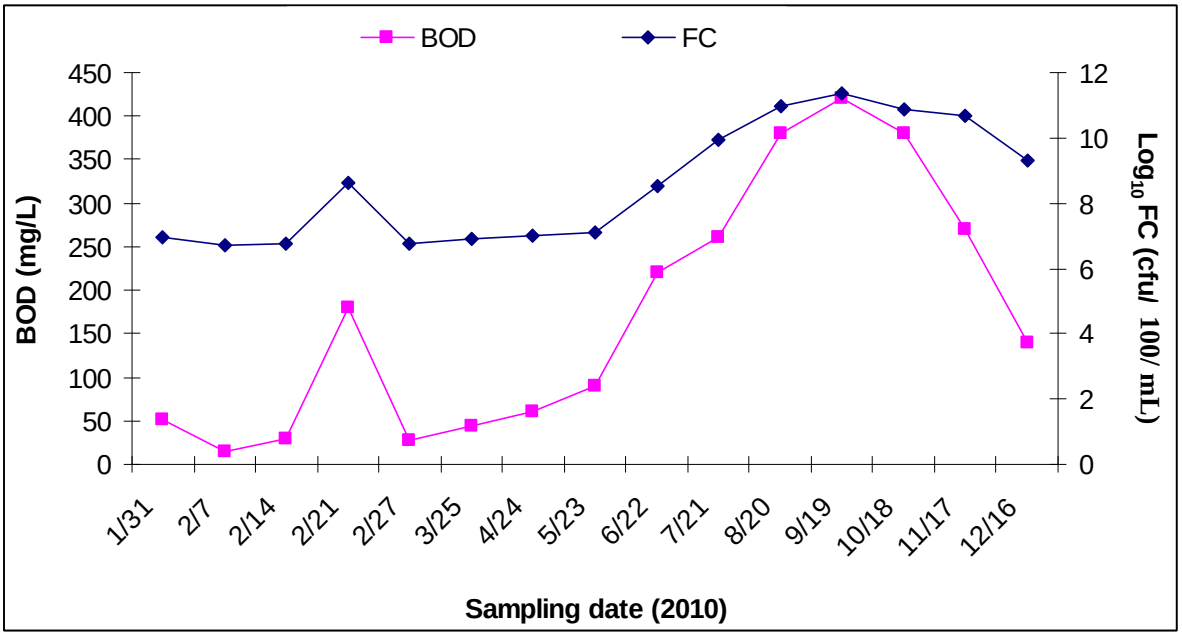

Fig. 6 BOD and FC progresses in the sampling site No. 1 during the monitoring time.

large difference between the minimum and maximum BOD values at all locations. The mentioned results reflect the capacity of system restoring under normal conditions, i.e., low pollution load and enough dilution from natural runoff, which can lead to a high self- purification capacity along the stream path.

3.7 TKN and Ammonia

Ammonia is the form of nitrogen most readily available to microorganisms. The presence of ammonia and other nitrogen sources in large amounts may result in eutrophication, leading to algal blooms and anoxic conditions. Location 2 contained the lowest ammonia and TKN concentrations, whereas location 3 was found to have the highest concentrations. Although it is included in the TKN, ammonia did not statistically linearly correlate with TKN. This might be due to the relative ease with which microorganisms consume ammonia compared with other nitrogen sources measured by the TKN method. Ammonia was positively related to turbidity, BOD and fecal indicators. Fig. 7 summarizes the ammonia and TKN concentrations in Zomar stream during the monitoring period at location 3.

3.8 Orthophosphate

Orthophosphate concentrations were the highest at location 3 followed by location 1 (Fig. 8). Both locations are surrounded by agricultural areas, which may contribute to these relatively elevated levels. This is in addition to the contribution of a wastewater outlet at location 3 and the Zomar stream inlet at location 1. Strong correlation was observed between orthophosphate and nitrate in both locations. Almost all high concentrations of orthophosphate were followed by algal blooms, as it was evident by visual observation of both water color (greenish) and deposits of algae on the stream edges at both location. This enforces the proposed role of phosphorus in the process of eutrophication.

3.9 Fecal Coliforms

Runoff, floods and sewage discharge release large numbers of microorganisms, including fecal indicators, into the stream. This was clearly demonstrated by a high fecal coliforms and fecal *Streptococcus* contents of all sites especially those adjacent to discharge sources (e.g., locations 1 and 3). Fecal coliforms and

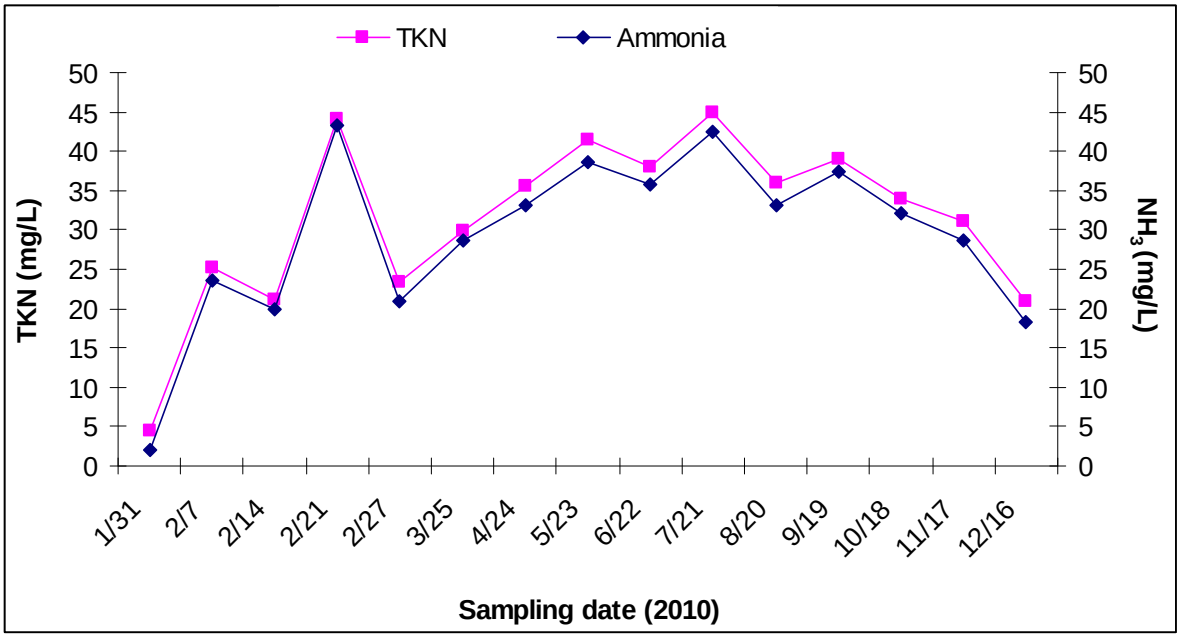

Fig. 7 TKN and NH_3 progresses in the sampling site No. 3 during the monitoring time.

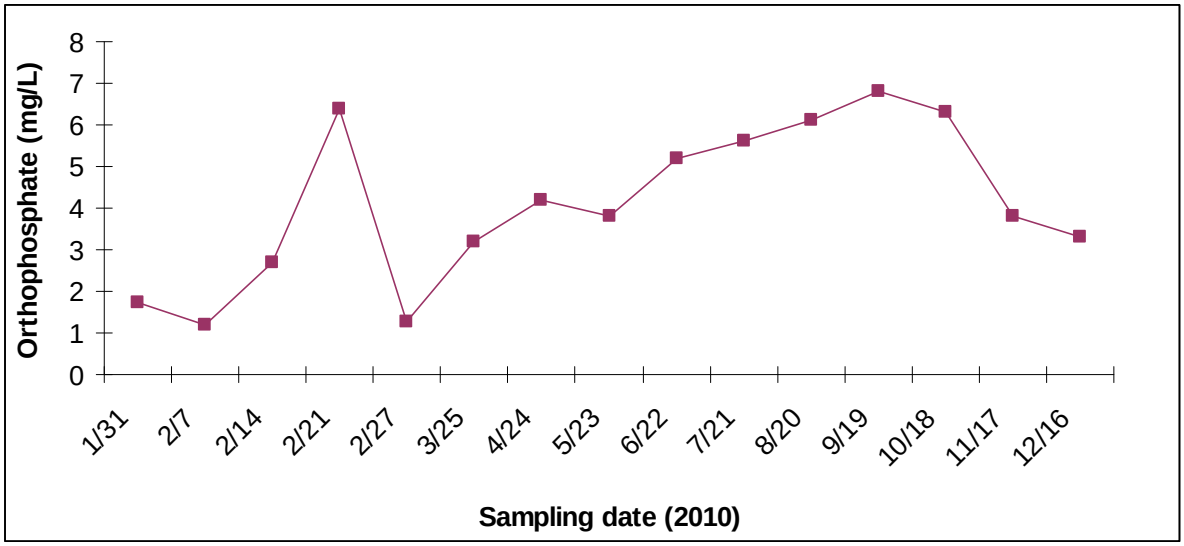

Fig. 8 Orthophosphate progress in the sampling site No. 1 during the monitoring time.

streptococci counts were relatively low in location 2 compared to locations 1 and 3. Location 2 seems to be affected by the pollution of location 1 as evident from the high levels of fecal streptococci found compared to that of coliforms. Streptococci survive longer than coliforms and are considered as an indicator of a relatively old sewage pollution.

Fecal coliform levels correlated well with fecal *Streptococcus* levels at locations 1 and 3, and with BOD at all locations, whereas fecal *Streptococcus* levels correlated with BOD at locations 1 and 3. Results for both fecal coliforms and fecal streptococci, which covered the four seasons, showed an increase during dry seasons, as illustrated in Fig. 9.

Results for fecal coliforms, which covered the whole monitoring period, indicated a decrease during winter and after almost every rainfall. This decrease can be attributed to floods, which flushes out both the

organics and microorganisms.

The bacterial counts were found to decrease with distance due to a dilution factor which is a result of rainwater tributaries along the stream. The values found for fecal coliforms indicated a decrease during the winter and after almost every rainfall, as shown in Fig. 10.

3.10 Pathogens

Four pathogens species were isolated from the collected samples: *E. coli*, *Klebsiella*, *Enterococcus*, and *Pseudomonas*. In general for the mid-stream samples, levels of pathogens showed decrease with rainfall events in all locations except location 1 because of its position nearby a wastewater discharge point.

In addition, the microbiology results show an increase in survival of *E. coli* and at less extent an increase in Klebsiella as wastewater discharge increases, while the density of *E. coli* declined immediately after each rain event. These findings are

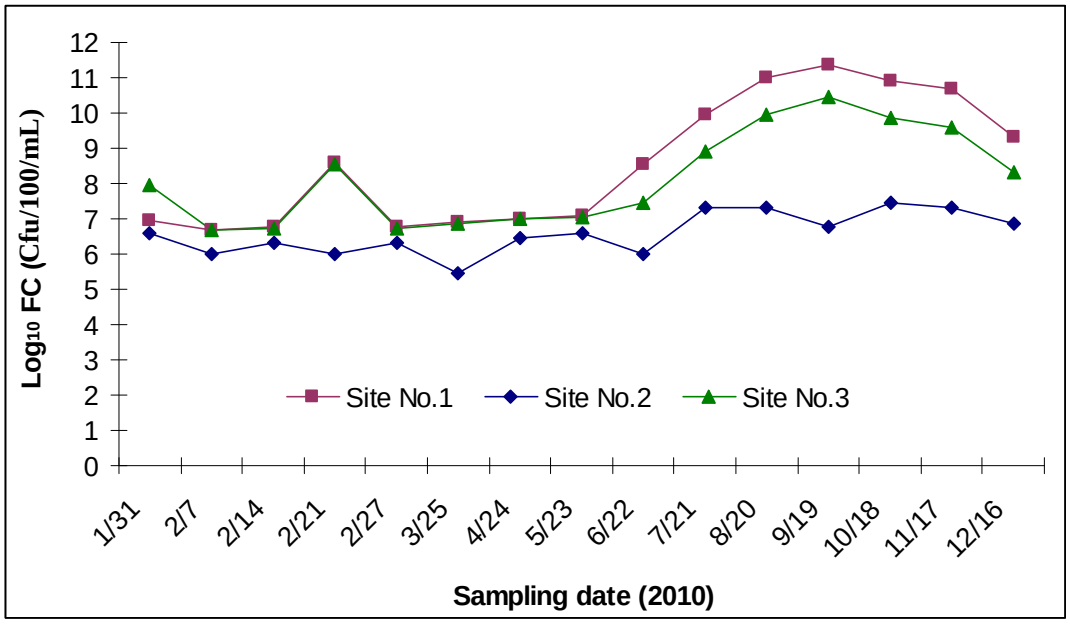

Fig. 9 Fecal coliforms from all locations during the monitoring period.

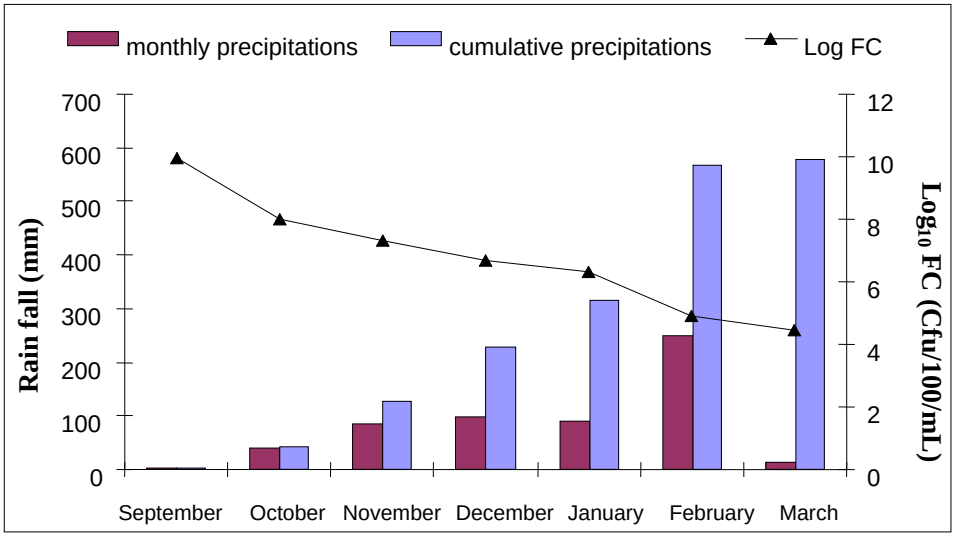

Fig. 10 Relation between bacterial activity and monthly and cumulative rainfall (mm) at sampling site No. 2 (Anbta) in the year 2010.

in agreement with results obtained by Lopez-Torres et al. [10] and Carlucci and Pramer [11], suggesting that the organic load improves the survival of these species. *E. coli* and *Enterococcus* densities were correlated much strongly with the cumulative rainfall variables than the other microbiological indicators. The presence of fecal and total coliforms is affected by the amount of stream discharge, which clearly can be noticed from the data collected for location 2. Results showed that fecal indicators and pathogenic bacteria survive longer in sediments than in the overlying water. It has been proposed that sediments serve as sinks of fecal bacteria with a potential pollution of bathing water more than lying. This result (Fig. 11) is in accordance with previous studies [12-14].

The ability of microorganisms to survive in aquatic sediments implies that fecal coliforms detected in the water column of streams may not always indicate recent contamination but may be a result of sediment resuspension [15]. Since microbial activity in sediments is greatly encouraged by the presence of organic matter [16, 17], it is possible that in nutrient-rich sediments microorganisms may survive for a very long time [18].

Accurate prediction of pathogen counts and occurrence in Zomar stream is an attractive risk assessment [19, 20]. Results indicate that there were a broad range of concentrations for indicator and pathogenic bacteria in response to hydrological results due to a variance of rainfall and discharges accompanied by temporal and spatial conditions coupled with limited pathogen data information; so that indicator bacteria (fecal and total coliform) will likely continue to be target microorganisms in the future [21, 22]. The *E. coli* load in sediment was investigated, as sediments are presumed to be an

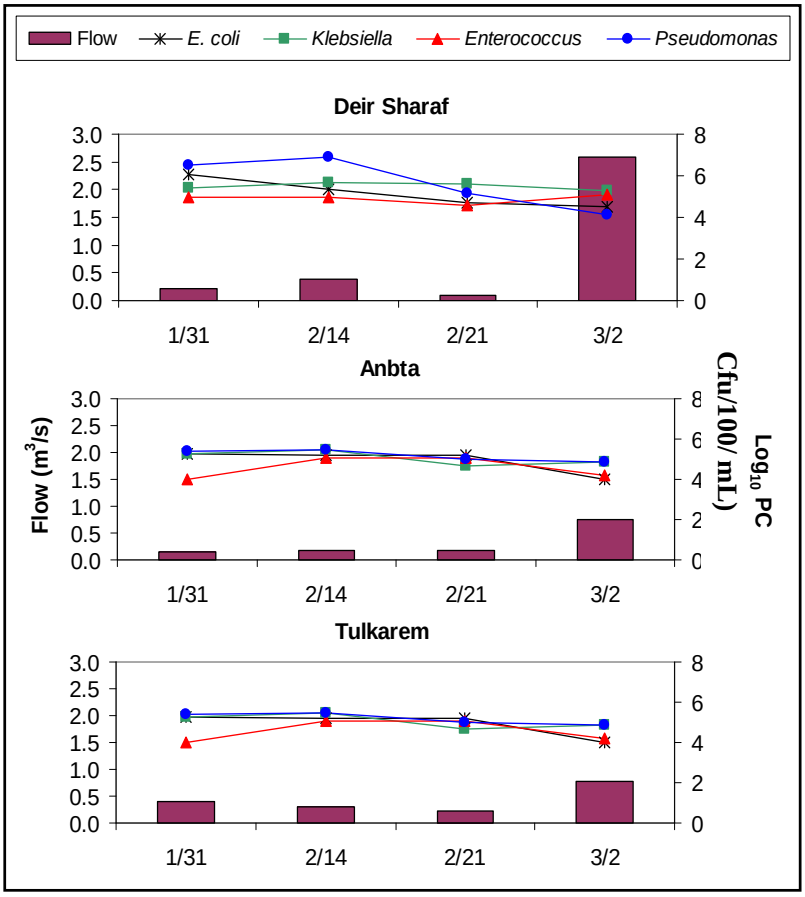

Fig. 11 Relation between PC (pathogens' counts) and flow discharge.

important mode of transport for fecal bacteria and pathogen to the water stream [23, 24].

4. Discussion

Results of this study indicated slight differences among the EC values measured at all locations, however, relatively high differences were recorded for BOD, ammonia and DO. These differences justify somehow the performance of these tests over a narrow testing area and prove that there is a real differentiation between the locations chosen. As indicators of organic pollution, BOD levels were found not to vary in a significant extent for locations 1 and 3 (both sites were proved to be highly polluted than location 1).

Fecal coliforms and fecal *Streptococcus* levels had similar variations in all locations studied, with the exception of location 2 where the levels of both bacteria varied considerably. Despite the fact that location 2 seems to be affected by pollution coming from location 1, the variation in the levels of fecal coliforms and fecal streptococci may be due to the dilution effect and the distance between the two location sites. In general, coliform bacteria was found to be more developed in settled samples than in running samples. The rational behind of such a behavior can be based on the typical biofilm formed by bacteria easier at settled than in running sites. This biofilm normally favors the bacterial growth and prolongs their residential time.

Turbidity was found to vary significantly according to fecal coliforms and *E. coli* levels during the monitoring period. This may be explained by algal growth and depletion of CO_2, which is conversely related to pH. In addition, pH was found to correlate negatively with EC, temperature, ammonia and TKN in both locations 1 and 2. These factors (temperature, ammonia and TKN) are important in the process of algal growth and therefore could be considered to be a factor controlling CO_2 and consequently, affecting pH values. Similar findings were depicted by Schulze et al. [25]. Algal blooms, which are often initiated by an overload of nutrients, cause a dramatic fluctuation of pH over a few-hours period; which might greatly stressing local organisms.

DO concentrations in surface waters are influenced by several factors. For this reason DO results are considered by many researchers very difficult to interpret [25]. In this study, DO concentrations ranged from 3.9 mg/L to 8.2 mg/L and varied significantly between various locations and within the same site. The positive correlation between turbidity and DO can be explained by the water turbulence, since increasing turbidity will increase the chance of molecular oxygen to be dissolved in water. The negative correlation of DO with temperature is well documented [25, 26]. Fecal coliforms are known to be facultative in aerobes, and when present in high concentrations of oxygen. However, our finding was somewhat different from that reported by Guillen et al. [27], who indicates that DO was positively correlated with fecal coliforms. This discrepancy between the results of the two studies may be attributed to other factors such as temperature and level of pollutants. Unpolluted natural waters have a BOD of 5 mg/L or less [25]. The BOD levels at all locations in this study were higher at least for one sampling occasion. Interestingly, BOD levels correlated well with nutrients (ammonia and TKN), turbidity and fecal coliforms. These positive correlations can be explained by the fact that the presence of nutrients under normal conditions supports the growth of bacteria as well as other microorganisms, leading to higher BOD levels together with an increase in the fecal coliform count.

Orthophosphate in the water comes mainly from fertilizers, and generally, an excess of phosphates enters water from wastewater treatment plants, sewage and soils. In recent years a change towards a more intensive agricultural production such as animal breading has been observed. This enhancements of agricultural activities resulted in a buildup of soil phosphorus to levels rarely encountered in the past.

Consequently, there is increasing potential for phosphorus losses to surface water [28].

Nitrogen levels follow a pattern similar to that of BOD and also seem to be affected by flow discharging. At the beginning of storm event, the pollution concentrations show dramatic temporal shifts, reflecting the so-called first flush effect in the stream then the concentration decreases as the storm proceed. The amount of rain and consequently the discharge is not quite enough to continue a dilution or self restoration processes for the stream. The problem seems to get more complicated within the summer time. In the summer, high evaporation and absence of precipitation concentrate the pollutants, leading to restricted growth for few types of pathogens, rather than natural digester and other type of common flora. The water eluted from sediments shows an increase in nitrogen concentration, which might be referred on nitrates absorption by plants root near the edges that lead to a more concentrated amount. Low nitrate in running samples is mainly due to the absence of proper time for oxidation. In location 3, results showed a limited nitrification processes where a sharp decrease in the ammonia level accompanied by a more moderate increase in levels of nitrate.

Location 2 had the lowest ammonia concentrations, while in the site No. 2 the highest concentrations were found. This result might be due to a relative ease with which marine organisms consume ammonia. The highest orthophosphate concentrations were at location 3 followed by location 1. Both locations are surrounded by agricultural areas besides sewage, which may contribute to these relatively high levels [29]. Almost all high concentrations of orthophosphate were followed by algal blooms, as evident by visual observation of both water color (greenish) and the deposits of algae. This enforces the proposed role of phosphorus in the process of eutrophication. Orthophosphate concentrations, however, slightly deviate during the course of the streams' flowing.

The concentration of nutrients at location 1 enhances the persistence of microorganisms, because this location is subjected to a continuous sewage discharge with a high supply of nutrients that keep the bacterial community active and thus lowering the stream ability for self purification at this site. On the other hand, location 2 shows a different behavior since its sampling point is in a remote distance from the sewage discharge point. The restoration process was clearly seen during samples' collection from location 2. For example, ammonia concentration decreases with a discharge event, because the main source of pollutants comes from sewage point nearby location 1. This promotes enough time for purification and natural bio-digestion for different kinds of organic pollutants. Location 3 also shows different behavior from the other two locations, since its sampling point lies at the end of stream and serves as collector for different source of pollutant along the stream path. In addition, this site is encompassed by cropping lands and is close to the discharge of sewage system serving the Tulkarem district.

There are no standardized criteria for phosphates; however, the following criteria can be assumed: (1) to prevent the development of biological nuisances and to control eutrophication, orthophosphate should not exceed 0.05 mg/L in a stream discharging into a reservoir, and the concentration should not exceed 0.02 mg/L within a reservoir [29]; (2) restoration of most eutrophic waters requires the reduction of nonpoint inputs of P and N [30]; (3) increased growth of algae and also aquatic weeds can degrade water quality and recreational as well as industrial activities. As overabundant nuisance plants die, bacterial decomposers proliferate; as they work to break down plant matter, the bacteria consume more DO from the water. The result can be oxygen shortages. Eutrophication plays a role in the loss of aquatic biodiversity.

Pathogenic bacteria count (except *E. coli* in settled samples) changed with heavy rain that caused an

increase in stream flowing. Overall, seasonal variation in the rates and types of fecal inputs, environmental conditions that influence the persistence of enteric bacteria and hydrological conditions that enhance the transport potential of enteric pathogens within the landscape are factors that may contribute to the seasonality in outbreaks of enteric disease in semi arid climates.

Seasonal variations were prominent in almost all of the pollution indicators. Several factors can be used to justify such variations. The highest concentration of fecal indicators was found in an area receiving land runoff during the rainy season. In another study and during the summer period, no countable *E. coli* was detected in all sampling points, whereas in autumn the organism was found in most of sampling points indicated in the study [31]. In a study by Vidal and Lucena [32], the impact of heavy rains on the microbiological quality of water persisted for few days and was dependent on the amount and density of rain and weather conditions after the rain episode.

5. Conclusions

The study results demonstrated that high levels of pollutants are associated with sewage input and runoff. Most of the parameters varied with location and season. Understanding the seasonal variation may be helpful in determining actions needed to minimize pollution sources, as well as other risks associated with pollution. The major pollution source is the raw sewage discharge from Nablus and Tulkarem cities into the Zomar stream. This source has the potential to change the fundamental nature of the ephemeral stream, converting it into a defected sewage conduit with permanent base flow running. The Zomar stream shows a semi-self-purification mechanism that partly treats the sewage and reduces the organic load in the water.

References

[1] J. Gasana, J. Morin, A. Ndikuyeze, P. Kamoso, Impact of water supply and sanitation on diarrhea morbidity among young children in the socio economic and cultural context of Rwanda (Africa), Envir. Res. 90 (2002) 76-88.

[2] S. Sulaiman, Z. Mimi, S. Khayat, Using biological indicators to characterize the natural flow regime in wadi zomar stream/palestine, Asian Journal of Applied Sciences 4 (7) (2011) 685-701.

[3] A. Brandeis, Alexander Stream Master Plan, Alexander River Restoration Project Press, 2003.

[4] OPTIMA, D11.2 the Zomar stream-Wadi Zomar Basin. Optimization for Sustainable Water Resources Management, 2007.

[5] Standard Methods for the Examination of Water and Wastewater, 21st ed., National Governmental Publication, American Public Health Association (APHA), Washington DC, 2005.

[6] K. Grasshoff, Determination of pH, in: K. Grasshoff, K. Kremling (Eds.), Methods of Seawater Analysis, Verlag-Chemie, Berlin, 1983, pp. 85-97.

[7] C. Keeper, Quality Assurance Project Plan, Lower Kenai Peninsula Watershed Health Project: Citizens Environmental Monitoring Program, Prepared for: US EPA Region 10 and State of Alaska Department of Environmental Conservation of Air and Water Quality, 2nd ed. 2000.

[8] A. Donnison, R. Cooper, Enumeration of fecal coliforms and *Escherichia coli* in New Zealand receiving waters and effluents, Environ. Technol. 11 (1990) 1123-1127.

[9] Standard Methods for the Examination of Water and Wastewater, 19th ed., American Public Health Association (APHA), National governmental publication, Washington DC, 1995.

[10] A. Lopez-Torres, L. Prieto, T. Hazen, Comparison of the in situ survival and activity of *Klebsiella pneumoniae* and *Escherichia coli* in tropical marine environment, Microb. Ecol. 15 (1988) 41-57.

[11] A. Carlucci, D. Pramer, An evaluation of factors affecting the survival of *Escherichia coli* in seawater: Experimental procedures, Appl. Environ. Microbiol. 8 (1960) 243-247.

[12] N. Ashbolt, G. Grohmann, C. Kueh, Significance of specific bacterial pathogens in the assessment of polluted receiving waters of Sydney, Water Sci. Technol. 27 (1993) 449-452.

[13] R. Ghinsberg, P. Leibowitz, H. Witkin, A. Mates, Y. Seinberg, D. Bar, et al., Monitoring of selected bacteria and fungi in sand and seawater along the Tel-Aviv Coast, MAP Tech. Rep. S 87 (1994) 65-81.

[14] J. Howell, M. Coyne, P. Cornelius, Effect of sediment particle size and temperature on fecal bacteria mortality rates and the fecal coliform/fecal streptococci ratio, J. Environ. Qual. 25 (6) (1996) 1216-1220.

[15] P. LaLiberte, D.J. Grimes, Survival of *Escherichia coli* in lake bottom sediments, Appl. Environ. Microbiol. 43 (3)

(1982) 623-628.

[16] N.F. Millis, Microorganisms and the aquatic environment, Hydrobiologia 1176/1177 (1988) 355-368.

[17] C.M. Ferguson, Faecal indicators and pathogens in water and sediment of the Georges River, M. Sc. Thesis, Uniersity of Technology, Sydney, 1994, p. 166.

[18] C.M. Davies, J.A.H. Long, M. Donald, N.J. Ashbolt, Survival of faecal micro-organisms in marine and freshwater sediments, Appl. Environ. Microbiol. 61 (5) (1995) 1888-1889.

[19] USEPA (U.S. Environmental Protection Agency), Protocol for Developing Pathogen TMDLs, EPA 841-R-00-002 Office of Water (4503F), United States Environmental Protection Agency, Washington DC, 2001.

[20] R. Coffey, E. Cummins, M. Cormican, V.O. Flaherty, S. Kelly, Microbial exposure assessment of waterborne pathogens, Hum. Ecol. Risk Assess 13 (2007) 1313-1351.

[21] A. Sadeghi, J.G. Arnold, A SWAT/microbial sub model for predicting pathogen loadings in surface and ground water at watershed and basin scales, in: Total Maximum Daily Load (TMDL) Environmental Regulations: Proceedings of the March 11-13 Conference, Fort Worth, Texas, USA, 2002, pp. 56-63.

[22] Y.Q. Tian, P. Gong, J.D. Radke, J. Scarborough, Spatial and temporal modelling of microbial contaminants on grazing farmlands, J. Environ. Qual. 31 (2002) 860-869.

[23] R. Jamieson, R. Gordon, D. Joy, H. Lee, Assessing microbial pollution of rural surface waters: A review of current watershed scale modeling approaches, Agricultural Water Management 70 (2004) 1-17.

[24] G.W. Characklis, M.J. Dilts, O.D. Simmons, C.A. Likirdopulos, L.A.H. Krometis, M.D. Sobsey, Microbial partitioning to settable particles in storm water, Water Research 39 (2005) 1773-1782.

[25] D.L. Schulze, J.S. Eggers, L.R. Esser, Water quality studies red rock and Saylorville Reservoirs Des Moines River, Lowa, Annual Report, Department of the Army, Rock Island District, Corps of Engineers, Rock Island, IL, 2001.

[26] J. Bartram, G. Rees, Monitoring Bathing Water, E & FNSPON, 2000.

[27] G. Guillen, J. Maldonado, S. Simmons, Evaluation of alternative bacterial indicators for use in determining compliance with water quality criteria, in: Proceedings of the National Water Quality Monitoring Council, Austin, Texas, 2000.

[28] J. Rodecap, "Excess phosphorus is detrimental to water", Water Watch Newsletter. Maquoketa River Watershed, 2000.

[29] Environmental Protection Agency (EPA). Implementation Guidance for Ambient Water Quality Criteria for Bacteria 1986, U.S. Government Printing Office, Washington DC, 1986.

[30] S.R. Carpenter, N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, V.H. Smith, Non-point pollution of surface waters with phosphorus and nitrogen, Ecological Applications 8 (3) (1998) 559-568.

[31] M. Divizia, V. Ruscio, D. Donia, E. ElGhazzawi, E. Elcherbini, R. Gabrieli, et al., Microbiological quality of coastal seawater of Alexandria, Egypt. Ann. Ig. 9 (4) (1997) 289-294.

[32] J. Vidal, F. Lucena, Effect of the rains on microbiological quality of bathing waters in Mediterranean areas, Technical Feasibility of a priori Measurement Approach for Managing Bathing Water Quality Report, Sitges, Spain, April 1997.