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Professional paper

ASSESSMENT OF WATER QUALITY, THROUGH MICROBIOLOGICAL AND PHYSIC-CHEMICAL ANALYSIS OF DUKATI STREAM, VLORA ALBANIA

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Abstract

Water pollution is a global concern in urban and rural communities. Water is important in ecological and social aspects. The monitoring of local water sources is important for water quality assessment. Water pollutants have an anthropogenic and natural origin. Fecal coliform bacteria are the main bioindicator for water quality. The high level of fecal coliforms can affect aquatic biodiversity but also can be a health risk to humans. In this study, we assess the water quality of the Dukati stream, in Vlora city, Albania. The water stream is used for agriculture, animal farming, and the manufacture of inert material at some points. Our study focuses on the microbiological and physic-chemical analysis of the Dukati stream. This study was conducted from January 2021 to December 2021. Water samples were collected at eight different station points. The monitoring of water quality was made every month, for each season. Microbiological monitoring for fecal coliforms was done using MPN methods. Physic-chemical analyses are based on the standard method for water quality. Stations six and eight have the highest level of fecal contamination. These stations are near inhabitant areas and in the stream delta. Fecal pollution has a seasonal variation. Temperature seems to affect the increase of bacterial contamination. This result corresponds with a high level of anthropogenic factors in these sites. Based on these results, periodic monitoring can improve the water quality management.

Keywords: Pollutant, water quality, fecal coliform, anthropogenic factor

1. Introduction

Fresh water reserves such as rivers, lakes, and lagoons provide many services to human society and the planet. Rivers and stream water are habitats for many species and have major values in ecological aspects. Mostly they are used as water supply. These ecosystems are threatened by anthropogenic factors that can lead to the loss of biodiversity and human health issues. (Pereira, 2007, Maffei et al., 2009). The main pressures on surface water bodies are pollution from sewage, agriculture, urban waste, and industrial sources, which lead to nutrient enrichment, chemical pollution, and habitat changes due to morphological changes. (Crouzet et al. 2000). The monitoring of water quality has a major role in the preservation of biodiversity and prevention of human diseases. Water quality assessment is based on the monitoring of the microbiological presence of bacteria and physicochemical parameters. (Gray, 1994; DWAF, 1996; USA-EPA, 1999). Pathogenic organisms are found in every ecosystem, but microbiological contamination with fecal bacteria is considered to be a crucial alert throughout the water. (Bayoumi Hamuda & Patko 2012). The most used microbial indicators for water quality evaluation are bacteria such as: coliforms, fecal coliforms, and fecal streptococci. (Arnone et al., 2007).

Fecal coliforms in body water have a different sources such as: warm-blooded animals and humans, wastewater, runoff from animal farms, and nonfunctional septic systems (Meybeck, 1989; Furuse et al., 198; Stein et al., 2007; Chigbu et al., 2005).

The presence of this bacteria in water is related to the interaction of chemical, and physical parameters. Temperature has an important role that influencing bacterial growth. Many studies have proved that temperature affects the presence of bacteria in water (Tiefenthaler et al., 2009). Elevate level of FC concentration shows a positive relation with precipitation (Cha et al., 2010), therefore increases in total annual precipitation will likely elevate contamination. Nutrient concertation, from farms can affect the microbial level in water bodies (Karakassis et al. 2001). Total Dissolved Solids (TDS) in water can also affect the water quality. Many studies revealed a pattern between TDS and water quality during season variation (Karakassis et al. 2001).

In this study, we assessed water quality, through microbiological and physic-chemical analysis of the Dukati stream. This stream is used during times for agriculture, farming, and also at some point for industrial purposes. Dukati village is situated in the southern part of Albania, in Vlora city. The Dukat valley is surrounded by the Ceraunian Mountains and opens in the north towards Vlora Bay. This site is part of the Orikumi Multicipaty an area with important historical contributions (Shpuza et al., 2020). The Dukat valley is irrigated by the Dukat stream, which takes a source near Llogora crosses through Dukat, Orikumi, and then flows into the sea. During the flow, many springs, of karstic origin join the stream (Eftimi et al., 2023). This area is also rich with biodiversity values high in animal and vegetation species.

2. Materials and methods

Study area

The Dukati stream crosses the valley of Dukati, in the southern part, of Albania, in Vlore. This stream takes source near Llogora and Dukati village. The stream crosses Dukati Valley then Orikum and flows in the sea. It has been used during time by the inhabitants of the region, for agriculture and farming. During this study, we analyzed the water quality of this stream based on the microbiological and physicochemical analysis.

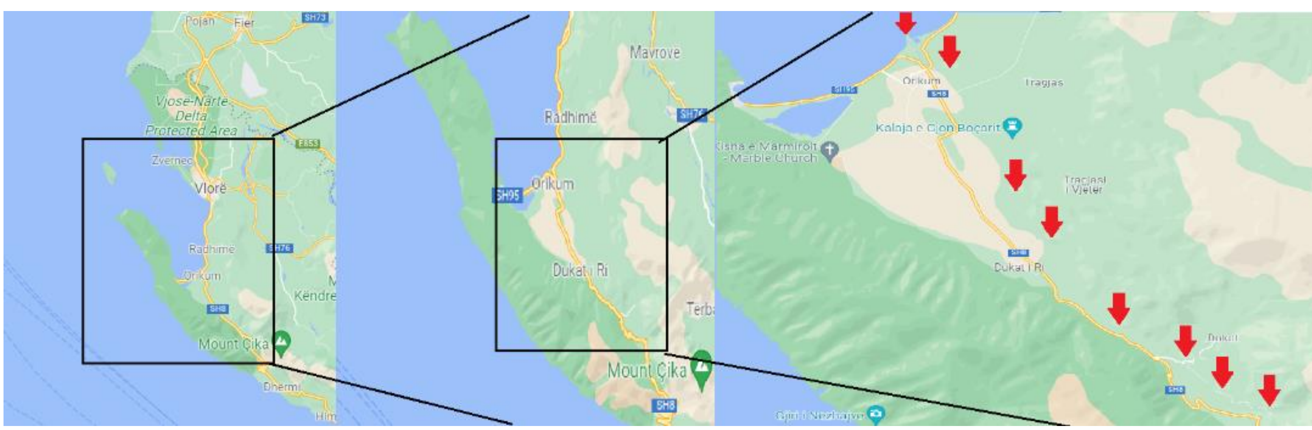

Figure 1: Study area zoomed in from Vlora (1) and Dukati region (2)
(Source: Google maps modified by Kiçaj et al., 2023)

Sampling collection

This study was carried out within the time from January 2021 to December 2021, including four seasons: winter, spring, summer, and fall. The samples were taken in eight stations along the Dukati stream. Station 1 in Dukati village, the second station is Komhilli Spring, the third station is near the Mosques, the fourth station "Eritua", the fifth station "Dry Spring", the sixth station "Is Izvory Bridge" the seventh station in Orikum, and eighth station the delta stream in the sea.
Sampling was carried out by the World Health Organization ISO 5667-6:2020 Water quality — Sampling — Part 6: Guidance on sampling of rivers and streams and ISO 19458:2006(en) Water quality — Sampling for microbiological analysis (ISO 5667-6:2020; ISO 19458:2006).

Table 1: *Geographic coordinates of sampling stations evaluated with GPS device.*

Station	Altitude	Longitude
1	40°14'49.53" N	19°33'44.88" E
2	40°14'58.67" N	19°37'45.67" E
3	40°15'4.13" N	19°33'47.85" E
4	40°14'44.19" N	19°33'32.92" E
5	40°19'19.28" N	19°29'5.49" E
6	40°20'13.78" N	19°28'13.1" E
7	40°20'24.37" N	19°28'11.11" E
8	40°20'24.37" N	19°28'11.11" E

*(**Source:** Data by Kiçaj et al., 2023)*

Microbiological analysis

Microbiological sampling was carried out by the World Health Organization,
Water quality — sampling for microbiological analysis (ISO 5667-6:2020; ISO 19458:2006). For the bacteriological analysis of the water samples, sterile 500 ml bottles were used to collect samples from the surface water (10–30 cm) at each station. The samples at the time of receipt were placed in a thermo box and transported within 2 hours to the laboratory (ISO 5667–5:1991). This mode of transport does not allow the multiplication of bacteria. Samples were analyzed on the same day they were collected.
The microbiological analysis was carried out in the Laboratory of Microbiology at the Faculty of Technical and Natural Sciences, University "Ismail Qemali" of Vlora. The sampling and the tests were performed by the International Standard Methods (ISO 1991; CEC 1978; WHO 1984; ISO 1999; UNECE 1994; Camper et al. 1996). MPN index was used for the evaluation of total coliform and fecal coliform in water. Total and fecal coliform was determined by MPN methods and EC media in a combination of 3 tubes (Bakaj et al., 2017; Bakaj et al., 2022). MPN index was calculated using the MPN statistical tables and is expressed as the number of organisms per 100 ml (MPN/100 ml).

Physic–Chemical Analysis

In this study microbiological and some physic-chemical analysis of water samples, was performed using standard methods as described by APHA-AWWA-WEF and Directive 2000/60/EC of the European Parliament and the Council (APHA-AWWA-WEF 2005; Council Decision 77/795/EEC).
A total of 7 physicochemical parameters, which include pH, electrical conductivity (EC), turbidity, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), etc., from surface water systems were used for this study. A thermometer was placed at a depth of 10 cm to take the water temperature in situ. The other parameter was analyzed by using water probe AQUAREAD 2000.
Selecting these parameters for predicting bacterial contamination was based on several factors such as prior knowledge of the relationships of explanatory variables to coliform bacteria and prior knowledge in the literature of factors influencing microbiological organisms. Certain parameters were also selected according to their availability and importance. Total and fecal coliforms constituted the main variables in this study.

Analytical Statistics

Box plots and mean plots of FC distribution revealed seasonal changes in bacterial numbers and environmental conditions between station locations. Seasonal variability was examined using mean values for each month to increase the accuracy of the annual trend for each parameter and obtain a standardized and appropriate sample number
Spearman's correlation analysis in SPSS was used to determine the relationship between the bacterial levels and the variables. For differences between the components, the significance threshold was set at 0.01.

3. Results and Discussion

The goal of our research was to assess the quality of stream water using a thorough analysis that included data for microbiological parameters and physic-chemical variables.

Table 2: All sampling stations' descriptive statistics (MPN 100 ml^{-1}) are listed in the table

Statistics

	S1	St2	St3	St4	St5	St6	St7	St8
N Valid	12	12	12	12	12	12	12	12
Mean	317.067	58.667	54.950	169.417	13.167	401.500	138.350	466.333
Median	93.000	23.000	9.300	23.000	11.500	460.000	29.500	460.000
Mode	1100.0	23.0	9.2	15.0	.0	460.0	23.0	460.0
Std. Deviation	474.07	81.32	128.50	322.77	14.81	378.65	305.73	419.7431
Variance	224745.3	6613.69	16513.59	104184.81	219.42	143381.5	93475.5	176184.2
Skewness	1.294	1.774	3.375	2.602	.591	.958	3.351	.692
Kurtosis	.361	1.882	11.543	7.020	.698	.182	11.413	-.967

a. Multiple modes exist. The smallest value is shown

*(**Source**: Data by Kiçaj et al., 2023)*

We studied 8 separate sampling stations that were eventually distributed along the stream flow. A statistical description of the given data for all of the studied sites is presented in table 2. According to our analysis, two of the stations, S6 and S8, have higher coliform bacteria levels. These stations are near inhabitant areas (S6) and also near the delta of the stream (S8). The anthropogenic factor has a big impact on these stations. Also, station one has high level of fecal contamination, because is near Dukati village.

Table 3: All sampling stations' descriptive statistics of physic-chemical variables are listed in the table

Statistics

	FC	**T**	**pH**	**ORP**	**DO%**	**DO mg/l**	**EC ms/cm**	**TDS g/l**
N Valid	90	90	90	90	90	90	90	90
Mean	218.35	15.42	7.32	202.6438	.9423	8.9208	329.80	223.08
Median	43.00	15.00	7.31	171.2000	.9340	9.0400	330.00	230.00
Mode	23	15	7	171.20[a]	.93	8.86	242	195
Std. Deviation	346.726	2.406	.373	175.49929	.04922	.63839	80.099	49.573
Variance	120219.254	5.791	.139	30800.000	.002	.408	6415.812	2457.505
Skewness	1.839	.366	.851	3.205	.747	1.143	.880	.500
Kurtosis	2.081	.572	.212	9.229	.266	.560	1.272	.031

a. Multiple modes exist. The smallest value is shown

*(**Source**: Data by Kiçaj et al., 2023)*

The concentration of CF in surface waters tended to vary seasonally, with 75% of sites having substantially different average CF concentrations from season to season. However, only some of these sites experienced hydro-meteorological variability (Figure 2). The proportion of sites exhibiting signs of climate forcing varied with hydro-meteorological regimes, as did the season during which the maximum CF concentration occurred.

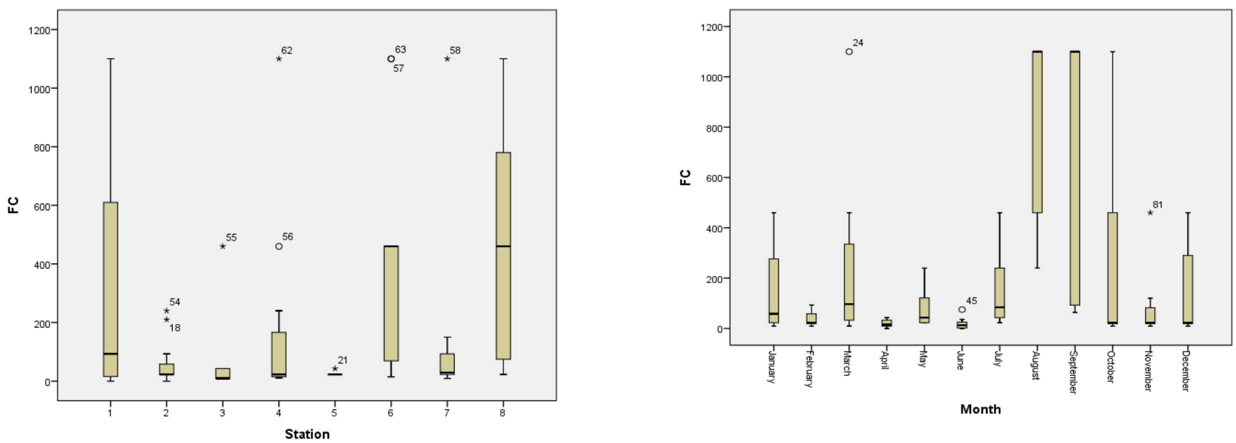

Figure 2: Box plot of microbial distribution in different sampling stations (A) and in different months (B), (**Source**: Data by Kiçaj et al., 2023)

According to the boxplot, we may understand that expect stations 6 and 8, stations 1 and 4 have an increase in fecal contamination only in August and September when the temperature is higher. The box plot of the microbial distribution in different sampling stations (Figure 2, A) and different months (Figure 2, B) shows some outliers in our data, especially in stations 1, 4, 6, and 8. Station 1 shows the outlier of 1.1 103 MPN 100 ml -1 in August and September. In stations 4, 6, and 8 this outliner is in March, July, August, and September. This seasonal variation is because of rainfall and increased values of temperature.

High concentration levels of FC during spring (March) and autumn (September) demonstrate that the observed positive relationship between precipitation and fecal contamination levels extends to the biennial periods, which are particularly relevant for climate change (Kistemann et al., 2002; Cha et al., 2010).

On the other hand, our data shows that fecal contamination peak was most frequent during the summer. This suggests that land-use impacts can be really important in the determination of seasonal variability of fecal contamination. Inputs of fecal waste from farms, wildlife, and human recreational activities, such as swimming and camping, tend to be highest over the summer (Meays et al., 2006a; Sigua et al., 2010).

Stations 1 and 6 are near inhabitant areas, so the anthropogenic impacts such as animal farming, and agriculture are highest in those stations. Station 8 is near the delta of the stream, so it is more affected by natural factors, such as water flow, rainfall, and anthropogenic factors. Mean plots and Box plots of FC distribution shows seasonal difference in bacterial contamination in each station.

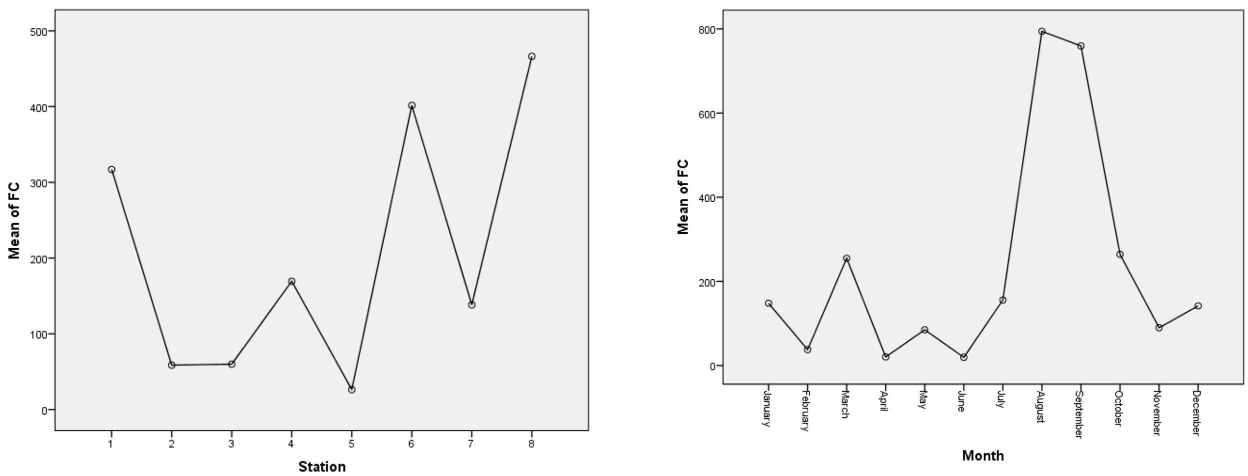

Figure 3. Mean plot of microbial distribution in different sampling stations (A) and in different months (B), (**Source:** Data by Kiçaj et al., 2023)

Based on the mean plot of fecal contamination stations 1 4, 6, and 8 have the highest values of contamination. The high level of contamination is during March, July, September, and October.

Table 4: Table of Spearman's correlation coefficient

Correlations

		FC	T
FC	Pearson Correlation	1	.221*
	Sig. (2-tailed)		.038
	N	90	90
T	Pearson Correlation	.221*	1
	Sig. (2-tailed)	.038	
	N	90	90

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

		FC	DO%
FC	Pearson Correlation	1	.277**
	Sig. (2-tailed)		.009
	N	90	90
DO%	Pearson Correlation	.277**	1
	Sig. (2-tailed)	.009	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

*(**Sourc**e: Data by Kiçaj et al., 2023)*

Based on the fact that FC values are influenced by a variety of environmental conditions, a statistical analysis of the correlations between physical parameters and coliform levels was conducted. Moreover, Spearman's correlation coefficient matrices for FC, month, and temperature were also constructed.

The correlation analysis shows a correlation between FC and Temperature, but also FC and physic-chemical parameters such as TDS, DO, and EC.

Table 5: Table of Spearman's correlation coefficient

Correlations			
		FC	**EC ms/cm**
FC	Pearson Correlation	1	.265*
	Sig. (2-tailed)		.012
	N	90	90
EC ms/cm	Pearson Correlation	.265*	1
	Sig. (2-tailed)	.012	
	N	90	90

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations			
		FC	**TDS g/l**
FC	Pearson Correlation	1	.264*
	Sig. (2-tailed)		.012
	N	90	90
TDS g/l	Pearson Correlation	.264*	1
	Sig. (2-tailed)	.012	
	N	90	90

*. Correlation is significant at the 0.05 level (2-tailed).

*(**Source**: Data by Kiçaj et al., 2023)*

Total suspended solids were combined with fecal and total coliforms to predict contamination by coliforms. Suspension solids may be associated with the survival of coliform bacteria. Suspended solids promote the survival of coliforms by protecting them from unfavorable conditions such as metal toxicity, UV radiation (An et al., 2002; Medema et al., 2003) and predation, and may also provide nutrients for coliform bacteria (Pachepsky & Shelton, 2011). Increasing Temperature, pH, DO levels, and a lack of salinity all accelerate the die-off rate. (An et al., 2002; Evanson & Ambrose 2006; Chigbu et al., 2005; Kirschner et al., 2004).

4. Conclusions

This study was focused on the water quality of the Dukati stream. The water quality was conducted based on the fecal indicator bacteria and physic-chemical parameters concentration levels. The sampling stations were selected at different points, to cover all the hydrodynamic characteristics of the stream. Based on our data stations 1, 6, and 8 are most contaminated with fecal coliforms.

These stations are near inhabitant areas so the anthropogenic factor has more influence in them. Stations 1 and 6 are exposed constantly to human pressure such as agriculture and construction industries. Station 8 is near the delta so is affected also by the water flow and all urban waste that can come during the stream flow. As the stream has an important role in economic and ecological aspects we suggest that periodic monitoring of water quality should be done to prevent the biodiversity loss and water quality management.

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