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[Research]

Assessment of surface water quality of Mencha River, Northeastern Algeria by index method

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ABSTRACT

Mencha River is one of the largest river in the region of Jijel, Algeria. The human activities such as urban discharges, industrial, agricultural and livestock have significant effects on the quality of water. Because of its importance in the agricultural activities and dense population residing at its banks, the river faces several challenges from various anthropogenic activities. This situation exposes surface water to a severe pollution. The objectives of this study are to use different indexes to assess the current pollution status in Mencha River. Indexes used in this study were Organic Pollution Index (OPI) and Microbiological Quality Index (MQI). Based on the data collected throughout this study, results indicated that the upper reaches of the river (station 01) has had good water quality (OPI=4, MQI=4), while the station 04 presented a poor quality (OPI=2.75, MQI=2.33). Indeed, several pollution sources exist in this site. The agricultural activity, among different sources, was the strongest point in the downstream section of the river, as it contains high amounts of chemicals, causing major decrement in water quality. The used indexes also showed that at stations 02 and 03, the water quality was moderate (OPI=3.25, MQI=3). This study can be used to support the evaluation of regulatory and monitoring decisions.

Key words: Surface Water, Pollution Organic Index (OPI), Microbiological Quality Index (MQI), Mench River

INTRODUCTION

Surface water quality has in recent years become one of the most pressing environmental concerns in many parts of the world (Ferreira *et al.* 2010; Perrin *et al.* 2014). Rivers have always been the most important resource of water. Along the banks of these rivers, ancient civilizations have flourished and most developmental activities are still dependent upon them (Gholami & Srikantaswamy 2009).

However, water has been altered significantly from its natural state, and human activities can affect its availability for various uses, both in quantity and in quality (Magesh & Chandrasekar 2013; Rashid & Romshoo 2013).

Faced with this reality, and coupled with the limited availability of freshwater for human consumption on our planet (Pal *et al.* 2013), the quality of the available water must be monitored.

The river water quality is governed both by man-made pollution and natural processes changes in the river hydrology (Ogwueleka 2015). River water pollution is seemingly a result of raw wastewater discharge, agricultural practices and industrial activities (Ribbe *et al.* 2008; Bayram *et al.* 2013).

Pollution from agriculture and wastewater discharge are regarded as the major cause of the surface water quality degradation and has attracted growing public concern (Zhang *et al.* 2008 ; Liu *et al.* 2009; Ongley *et al.* 2010 ; Tang *et al.* 2011; Darradi *et al.* 2012).

The Mencha River, considered in this study, is a major riverine system in the alluvial plain of Kaous, Northeast Algeria. This river contains contaminants from livestock farms and septic tanks located in adjacent villages. Quality indexes are useful in getting a composite influence of all parameters of overall pollution. Quality indexes make use of a series of judgments into a reproducible form and compile all the pollution parameters into some easy approach (Prasad *et al.* 2014). This study uses the Organic Pollution Index (OPI) and Microbiological Quality Index (MQI) to explore the characteristics of water quality of Mencha River and the resulting data may be used to provide scientific suggestions for river protection in the future.

The surface water quality of Mencha River has been understudied. In addition, the effect of agricultural activities on water quality has not been investigated. This study intends, therefore, to evaluate and assess the surface water quality of this river.

MATERIALS AND METHODS

Study area

The study area is located in the north-eastern part of Algeria (Fig. 1).The climate in the study area is of Mediterranean type with dry and warm summers, and also temperate and wet winters. 80% of precipitation occurs in the winter months (November through March). Average temperature is 09°C in January and 29°C in July. Agricultural wastes, fertilizers and raw sewage effluents constitute the predominant anthropogenic sources in the area.

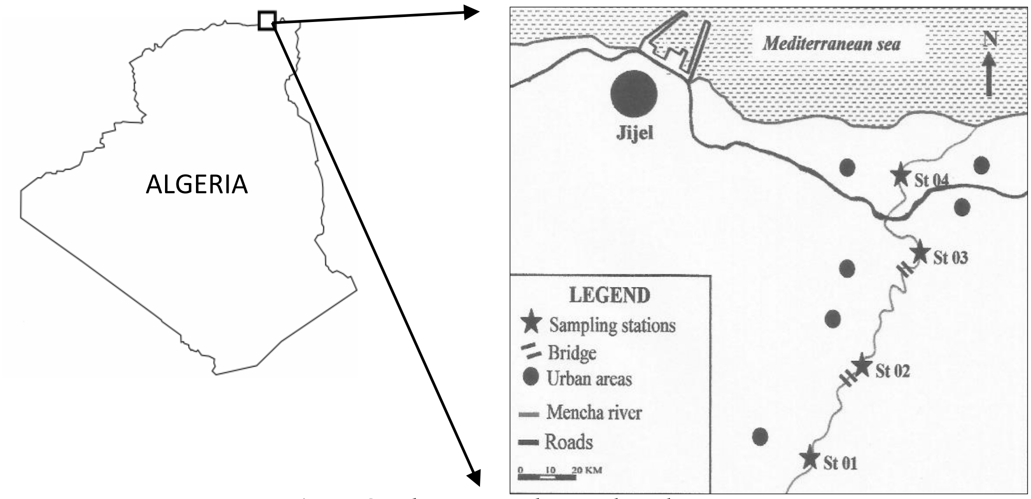

Fig. 1. Study area and sampling locations.

Sample and data collection

Inorder to determine the quality of water, the samples are collected from four sampling stations selected according to the point and non-point pollution sources mainly from agricultural and minor industrial activities. Water samples of 1000 mL glass bottles, were collected from February through May, 2015 in triplicates. These samples are collected in cleaned and well-dried brown bottles with necessary precautions. These bottles were labeled with respect to collecting points, date and time in order to avoid any error between collection and analysis. The water collection point was located at 30cm depth.

Analytical methods

Water samples were analyzed in the laboratory for biological oxygen demand (BOD_5), phosphate (PO_4), nitrite (NO_2), ammonium (NH_4^+), total coliform (TC), faecal coliform (FC) and faecal streptococci (FS).

The analytical methods used to evaluate the organic and bacteriological pollution of surface water are presented in Tables 1 and 2, respectively.

Table 1. Classes of organic pollution (leclercq & Maquet 1987).

Classes	BOD_5 (mg O_2.L^{-1})	Ammonium (mg N.L^{-1})	Nitrites (µg N.L^{-1})	Phosphate (µg N.L^{-1})	0PI*	Classes of organic pollution
1	<02	<0.1	<05	15	5.0-4.6	Null organic pollution
2	2.1-05	0.1-0.9	06-10	16-75	4.5-4.0	Low organic pollution Moderate
3	5.1-10	1.0-2.4	11-50	76-250	3.9-3.0	organic pollution High organic
4	10.1-15	2.5-6.0	50-150	251-900	2.9-2.0	pollution Very high organic
5	>15	>6.0	>150	>900	1.9-1.0	pollution

*OPI = average number of classes of 4 parameters.

Table 2. Classes of bacteriological pollution (Bovesse & Depelchin 1980).

Classes	TC (MPN.100 ml^{-1})	FC (MPN.100 ml^{-1})	FS (MPN.100 ml^{-1})	MQI*	Classes of bacteriological pollution
1	<2000	<100	<05	4.3-5.0	Null Fecal contamination
2	2000-9000	100-500	05-10	3.5-4.2	Low Fecal contamination
3	9000-45000	500-2500	10-50	2.7-3.4	Moderate Fecal contamination
4	45000-36000	2500-20000	50-500	1.9-2.6	High Fecal contamination
5	>360000	>20000	>500	1.0-1.8	Very high Fecal contamination.

*The average number of MQI classes is like calculating the OPI; TC=total coliform; FC=faecal coliform; FS=faecal streptococci.

The principle of the OPI is to spread the values of polluting elements in 5 classes (Table 1) and then determine, from its own measures, the number of corresponding class for each parameter and then to make the average (Leclercq & Maquet 1987).

For the calculation of the MQI, the limits of the classes (Table 2) were established by Bovesse & Depelchin (1980).

RESULTS

The results of OPI and MQI in sampling stations are shown in Tables 3-4 and Figes. 2-3. Downstream values of OPI were considerably elevated compared to upstream ones. The values were 04, 3.25, 3.25 and 2.75 for stations 01, 02, 03 and 04 respectively, which demonstrated low, moderate and high organic pollution (Table 3 and Fig. 2).

Table 3. Water quality conditions based on the assessment by using Organic Pollution Index (OPI).

Stations	OPI	Water quality
St01	04	Low organic pollution
St02	3.25	Moderate organic pollution
St03	3.25	Moderate organic pollution
St04	2.75	High organic pollution

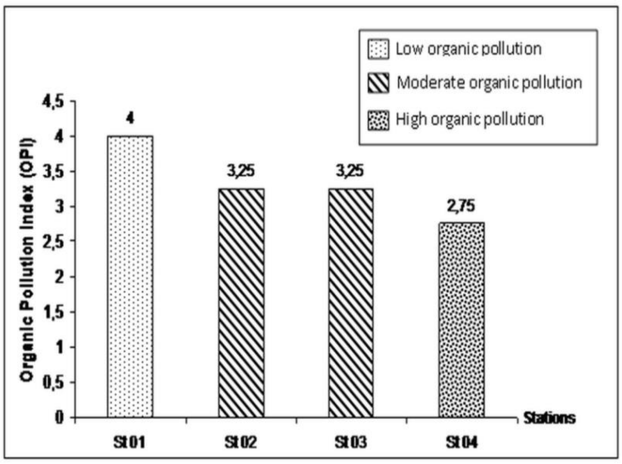

Fig. 2. Variation of the organic pollution index (OPI) for sampling stations.

The results indicate that high level of organic pollution is shown in station 04. This site was an agricultural area located near local villages. Indeed, in this part of river, population growth and development pressure often lead to more intensive land exploitation and thus accelerate the degradation of water capacity and quality. Many research studies have shown a close relationship between water quality and urban development. For example, Zhao *et al.* (2015) found that the industrial land use showed negative effect on water quality. Other researchers have revealed the relationship between urban land uses and phosphorus and also other pollutants in streams (Haidary *et al.* 2013; Wan *et al.* 2014).

Agricultural activities encompass many major forms of land use, including farming and raising livestock. Rashid and Romshoo (2013) found that excessive use of fertilizers has a significant impact on the deteriorating water quality of Lidder River (India) in the low lying areas of the catchment especially where land use is dominated by agriculture. Yadav and Kumar (2011) monitored the water quality of Kosi River in India and concludedthat industrialization, urbanization, and modern agriculture practices have direct impact on deteriorating water quality.In rural area (station 01), characterized by a very low urban coverage with the presence of old houses isolated and very limited agricultural activity, septic tank systems are considered to be an effective means of wastewater treatment provided they are designed, located and maintained satisfactorily (Macintosh *et al.* 2011; Kay *et al.* 2012).

At stations 02 and 03, no differences were observed in the organic pollution index of the surface water. These two suburban stations, are located between a rural area (station 01) and urban area (station 04). In this part of river and compared to that in rural area, population growth often lead to more intensive land uses and thus accelerate the degradation of water quality.

Therefore, surface water quality, is found contaminated with the domestic sewage water from drains of suburban localities. In this area, there is still direct discharge of septic tank effluent to adjacent river. Withers *et al.* (2011) reported in a typical English village that septic tank systems deliver variably high concentrations of highly bioavailable and/or potentially toxic nutrients to the stream network.

For the MQI, evaluation along the Mencha River revealed that all assessed stations were contaminated with fecal coliforms.

The observed results have definite fluctuation according to the location. The MQI ranged from 4 to 2.33 (Table 4).

Table 4. Water quality conditions based on the assessment by using Microbiological Quality Index (MQI).

Stations	MQI	Water quality (Fecal contamination)
St01	4.00	Low
St02	3.00	Moderate
St03	3.00	Moderate
St04	2.33	High

The levels of fecal contamination were low at station 01, located upstream of the river, moderate at stations 02 and 03, and high at station 04 located downstream of the river (Fig. 3). Low value of the microbiological quality index recorded at station 01 can be explained by the fact that there is less farming in this area and that water was not affected by massive inputs of wastewater. In addition, the area is characterized by a very low urban coverage. It is apparent that the land predominantly rural was the main cause for these results.Because of the higher level of urbanization and agricultural particles (livestock and poultry breeding), a significant amount of untreated wastewater was discharged into the river system which contribute to a high level of fecal contamination and deteriorated water quality.

The rapid growth of population and the versatile agricultural practices are suspected to profoundly increase the load of fecal bacteria, nutrients and other pollutants into the water (Frey *et al.* 2013; Walters *et al.* 2013). Indeed, Chidya *et al.* (2011), reported that elevated fecal coliform counts were measured in the urban area. Stations 02 and 03 were located in area widely known for its deficiency in wastewater treatment facilities. The fecal contamination of water in both areas is attributed to the presence of pathogenic microorganisms in the feces of humans following the emptying of the septic tank directly in the river.

The discharge from the septic tank is highly enriched in reduced inorganic nutrients and fecal indicator organisms suggestive of a health risk.

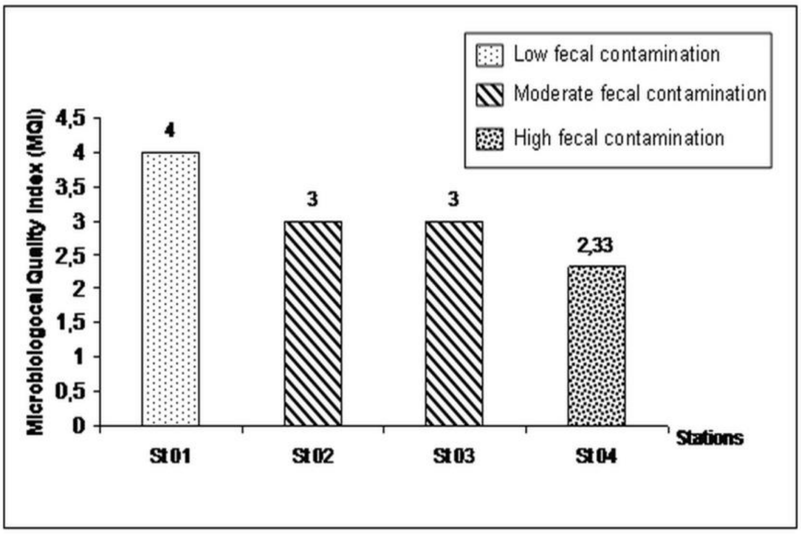

Fig. 3. Variation of the Microbiological quality index (MQI) for sampling stations.

CONCLUSION

Water quality indices are efficient and powerful tools for evaluating, organizing and communicating information on the overall quality of surface water bodies. OPI and MQI were evaluated in the present investigation by considering the physicochemical and microbiological parameters. The present research showed that:

1. The estimated OPI and MQI classified the average water quality at the upstream of the river as good (low organic pollution and low fecal contamination), poor in the downstream (high organic pollution and high fecal contamination) and moderate in the middle section (moderate organic pollution and moderate fecal contamination).

2. Results revealed that water quality of the Mencha River is generally affected by agricultural activities and dense population residing at banks. The best quality was found in the upper site (station 01) and the worst at the lower site (station 04).

3. Although, there is variation in the quality of water between rural and urban areas. The upper site exhibited good water quality as compared to the lower rural sites, mainly due to the effects of urban wastewater discharge, septic tanks and agricultural activities.

4. Thus, the study illustrates the useful application of Organic Pollution Index (OPI) and Microbiological Quality Index (MQI) for the interpretation of surface water quality data and identification based on pollution status. The main sources of pollution came from domestic wastewater and agricultural activities.

However, they contributed differently to each station with regard to pollution levels.

These results provide fundamental information for developing better water pollution control strategies for Mencha River.

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ارزیابی کیفیت آب سطحی رود منچا در شمال شرقی الجزایر با استفاده از شاخص‌ها

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۲-آزمایشگاه کنش های زیست محیطی ، دانشکده علوم و تکنولوژی، دانشگاه جیجل، صندوق پستی ۹۸، جیجل، ۱۸۰۰۰، الجزایر.

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چکیده

رود منچا یکی از بزرگترین رودها در منطقه جیجل الجزایر است. فعالیت های انسانی مانند پساب های شهری، صنعتی، کشاورزی و دامپروری اثرات معنی داری بر روی کیفیت آب دارند. این رود به خاطر اهمیتش در فعالیت های کشاورزی و جمعیت های متراکم انسانی در اطراف مخازن آن در معرض چالش های متعددی در اثر فعالیت های انسانی قرار دارد. این امر باعث می شود که آب های سطحی در معرض آلودگی شدید قرار گیرند. هدف این مطالعه استفاده از شاخص های مختلف برای ارزیابی وضعیت آلودگی جاری در رود منچاست. شاخص های مورد استفاده شامل شاخص آلودگی آلی (OPI) و شاخص کیفیت میکروب شناختی (MQI) بودند. بر اساس مطالعات جمع آوری شده در طول این مطالعه، نتایج نشان داد که قسمت های بالای این رود (ایستگاه ۰۱) کیفیت آب خوبی داشت (OPI = ۴، MQI = ۴)، در حالی که ایستگاه ۰۴ کیفیت ضعیفی داشت (OPI = ۲/۷۵، MQI = ۲/۳۳). در حقیقت چندین منبع آلودگی در این محل وجود دارد. فعالیت های کشاورزی در بین منابع دیگر قویترین نقطه در این بخش از رود بود که حاوی مقادیر بالایی از مواد شیمیایی است و سبب کاهش کیفیت آب می شود. شاخص های مورد استفاده نشان داد که در ایستگاه های ۰۲ و ۰۳ کیفیت آب متوسط است (OPI = ۳/۲۵، MQI = ۳). این مطالعه را می توان برای تقویت ارزیابی های تصمیم گیری تنظیمی و پایشی مورد استفاده قرار داد.

*مولف مسئول