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Determining Pollution Level for the Marine Environment Using the Pollution Load Index

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تقدير مستوى التلوث للبيئة البحرية باستخدام مؤشر حمل التلوث

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Abstract

Monitoring means Monitoring, Data, Indicators, Assessment, and Knowledge. Based on this context the Pollution Load Index (PLI), has been applied using the data obtained from the analysis of water and algae. Algae and Posidonia oceanic were considered as good candidates among the different species selected by the United Nation Environmental Program (UNEP). The concentrations of the metals (Zn, Pb, Cd, and Cu) were measured in two marine green algae namely *Ulva* sp and *Enteromorpha* sp, that were collected from four Sites, during the winter and summer seasons. The results of the PLI calculated showed that the values for Enteromorpha species were 1.2 indicating a polluted condition, while PLI values for Ulva species were 3.3. With regard to site B (Juliana area), the PLI value for Ulva species was found to be 4.1 indicating an acceptable condition while it was a clean condition for the Enteromorpha species at the same sites. Enteromorpha species is a good accumulator of heavy metals and could be also a good candidate for monitoring the Libyan coastline. The results also show that the PLI index could be an important tool for the assessment of the marine environment.

Keywords: *Heavy metals, Monitoring of the aquatic environment, Ulva, Enteromorpha, Pollution indices, Marine ecosystem status quality.*

الملخص

المراقبة تعني مراقبة البيانات، المؤشرات، التقييم والمعرفة. تأسيساً على ذلك، فإن مؤشر حمل التلوث تم تطبيقه أو حسابه باستخدام البيانات والنتائج المتحصل عليها لتركيز المعادن الثقيلة في عينات من مياه البحر وكذلك عينات من نوعين من الطحالب الخضراء وهما الأولفا والانتروموفا. تم اعتبار الطحالب وPosidonia oceanic مرشحين جيدين من بين الأنواع المختلفة التي اختارها برنامج الأمم المتحدة للبيئة (UNEP). تم قياس تراكيز المعادن (الزنك، الرصاص، الكادميوم، والنحاس) في طحالب بحرية خضراء هما *Ulva* sp و*Enteromorpha* sp، تم جمعهما من أربعة مواقع خلال فصلي الشتاء والصيف. أظهرت نتائج PLI المحسوبة أن قيم Enteromorpha كانت 1.2 تشير إلى حالة ملوثة بينما كانت قيم PLI لأنواع Ulva 3.3. فيما يتعلق بالموقع B (منطقة جوليانا)، تم العثور على قيمة PLI لأنواع Ulva لتكون 4.1 تشير إلى حالة مقبولة بينما كانت حالة نظيفة لأنواع *Enteromorpha* في نفس المواقع. تعتبر أنواع *Enteromorpha* تراكمًا جيدًا للمعادن الثقيلة ويمكن أن تكون أيضًا مرشحًا جيدًا لمراقبة الساحل الليبي. تظهر النتائج أيضًا أن مؤشر PLI يمكن أن يكون أداة مهمة لتقييم البيئة البحرية.

الكلمات الدالة: المعادن الثقيلة، رصد البيئة المائية، أولفا، إنتيروموفا، مؤشرات التلوث، جودة حالة النظام البيئي البحري.

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1. Introduction

Currently, environmental pollution is one of the problems that many countries face. Many countries have provided big budgets and efforts to monitor and remediate the impact of pollution, through several means of technology tools. Biological Monitoring of pollution by using living organisms *i.e* "Plants, animals, and microorganisms" which are explanted to detect pollution in a given ecosystem (Khatri and Tygi, 2015). Biological methods for monitoring the quality of water were first introduced by (Kolkwitz and Marsson, 1908). Bio-indicator organisms can be any biological species that defines a trait or characteristics of the environment. Algae are autotrophic organisms that represent the first trophic level in the ecosystem pyramid (Barinova, 2017). Algae are known to be good indicators of pollution of many types for the following reasons: i) Algae have wide temporal and spatial distribution, ii) many algal species are available throughout the year, iii) respond quickly to the charges in the environment due to pollution, iv) Algae are a diverse group of organisms found in large quantities, v) easier to detect and sample, and vi) The presence of some algae are well correlated with a particular type of pollution such as organic pollution (Ayodhya and Kshirsagar, 2013). The two species of Ulva and Enteromorpha were reported to be good bio-indicators for metal contamination (Ho, 1990).

Pollution levels of the aquatic Environment particularly by metals can be determined through the analyses of water, sediments, and organisms. The degree of contamination could be estimated using different indices such as the geo accumulation index. Igeo that estimate the enrichment of metal concentration in sediment. Other different methods have also been applied to assess the quality of the environment and the pollution statutes of the ecosystem by comparing the observed concentration with natural or preindustrial levels. The indices were quantitative measures of the degree of pollution in the aquatic environment (EL-Bady *et al*., 2013). The pollution load index (PLI), contamination factor (CF), degree of contamination (Cd), modified degree of contamination (mCd), and enrichment factor (EF) is other examples (Kowalska *et al*., 2018; Liu *et al*., 2018; Chung *et al*., 2016; Cho *et al*., 2015; Islam *et al*., 2015; Lai *et al*., 2013; Kim *et al*., 2011; and Karbassi *et al*., 2008).

The aim of the current work was to characterize the most common algae species distributed along the Benghazi city coastline that can be used as a bio-indicator of heavy metal pollution and also assess the degree of pollution using the pollution load index (PLI), in order to improve our knowledge on the state of the marine environment along the study area and to contribute to the development of sustainable environmental management and other related policies and informing policymakers on the in how to monitor and to improve the state of the environment through the easily understood and accessible information to the wider community about the state and condition of the coastal marine environment.

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2. Materials and Methods

2.1. Samples Collection

Samples were collected randomly from four different areas namely Al-Sabri area (A), Juliana area (B), Eshbilla area (C), and Alminah area (D) from the east coast of Benghazi city in eastern of Libya as shown in Fig. (1).

Figure 1. Map illustrate the study areas (A, B, C, and D), (Google earth, 2022)

2.2. Laboratory Analysis

Algae samples were collected then samples were attentively washed in tap water to remove salt, sand, and particulate matter, then rinsed in distilled water to remove any mineral particles and organisms adhering to the algal surface. Samples were dried ground and homogenized in the laboratory prior to the analysis. The samples were then dried on an Algal Herbarium paper 41.25 cm×28.75 cm at room temperature which was around 25oC. The powder was then kept in a plastic test tube with a cup until digestion.

2.3. Samples Digestion

Samples were digested using concentrated Nitric Acid (HNO_3) according to the methods of (Antonious *et al*., 2011; ASTM, 1990; and Jeffery *et al*., 1985) for the analysis of heavy metals. All the steps regarding quality control and quality assurance for the analysis have been taken. Digestion has been done in an acid-cleaned digestion test tube. Half gram (0.5 g) of dry grounded algae were placed in the digestion tube and then 5 ml of the concentrated nitric acid HNO_3. The test tubes were then put on a Shaker for 24 hours. The samples were filtered using

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Whatman paper No. 42. The samples were made up to volume in a 100 mL volumetric flask and the samples become ready for measurements.

Standard solutions have been prepared for all the metals studied (Cd, Pb, Cr, Zn, and Cu). The calibration curve was established for each element using the prepared standard. All glassware tubes were washed well before being used with 20% Nitric acid and with distilled water. All the determination of metals was done using Atomic Absorption Spectrophotometer (AAS, Analytic Jeha Nov AA300) at the laboratories of Ras-Lanuf petrochemicals Company. The data were then subjected to different statistical analyses using a program (SPSS) version 11.0.

The Pollution Load Index (PLI) which was developed by (Tomlinson *et al*., 1980) for determining the degree of pollution by heavy metals in each location, it was calculated using Eqns. (1 & 2) as;

$$PLI = log_{10}{}^{-1}\left(1 - \frac{Cp-B}{T-B}\right) \quad \ldots\ldots (1)$$

$$PLI = (CF_1 \times CF_2 \times CF_3 \times \ldots\ldots CF_n)^{1/n} \quad \ldots\ldots (2)$$

The value of PLI close to Zero indicates a heavily polluted area by heavy metals, whiles a value close to 1 indicates the presence of only baseline or a clean environment free from pollution by heavy metals (Gashi *et al*., 2017; Ghaleno *et al*., 2015; and Tomlinson *et al*., 1980).

3. Results and Discussion

The Pollution Load Index (PLI) has been mentioned before is a tool for the total assessment of the degree of pollution in the study area. It can be seen from the results of the PLI values (1, 2, 3, and 4), that there were differences between the pollutants. The closest index values to zero obtained were 1.0 and 1.2. It was recorded for Zn, Pb, and Cu. These results indicate pollution by these elements in Al-Sabri area (A) and Alminah area (D). The PLI results showed that all sites examined were generally uncontaminated by heavy metals except for site these sites. The reason for the variation of the PLI values obtained between species could be attributed to the differences in their abilities to accumulate metals, in which it appears that the *Enteromorpha sp* is accumulating more Pb than the *Ulva sp*.

The PLI value for the Zn Table (1) showed that all sites examined were generally unpolluted using the *Ulva sp* and only contaminated at site (A) for the *Enteromorpha sp* by heavy metals except for site (A) in which the value recorded was 1.2, while the value of the index reaches 9 at the port site (D) indicating a clean environment from this pollutant for the same species. The PLI values for the *Enteromorpha sp* at sites (B, C, and D) were found to be clean environments.

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Table 1. The values of the PLI for Zn for both Species.

Algae Species	Site*	PLI Value	Classification
Ulva	A	3.3	Moderate polluted
	B	4.1	Acceptable
	C	7.0	Clean
	D	7.7	Clean
Enteromorpha	A	1.2	Polluted
	B	7.7	Clean
	C	7.0	Clean
	D	9.0	Clean

*A: Al-Sabri area; B: Juliana area; C: Eshbilla area; and D: Alminah area.

The PLI value for the Cd Table (2) showed that all sites examined were not polluted by this metal in both species the *Ulva sp* and the *Enteromorpha* sp. The values were found to range 5.1-7.4 indicating a clean environment.

Table 2. The values of the PLI for Cd for both Species.

Algae Species	Site*	PLI Value	Classification
Ulva	A	7.4	Clean
	B	7.4	Clean
	C	7.0	Clean
	D	7.8	Clean
Enteromorpha	A	5.1	Acceptable
	B	5.4	Acceptable
	C	7.3	Clean
	D	7.4	Clean

*A: Al-Sabri area; B: Juliana area; C: Eshbilla area; and D: Alminah area.

The PLI values for the Cu Table (3) were 1.2 indicating a polluted site (D) and 3.3 at site (C) indicating a moderately polluted site. The values 5.3 and 5.4 were recorded for the sites (B and A) indicating acceptable conditions using the *Ulva sp*., while for the *Enteromorpha sp*, all the sites examined were found to range from moderately polluted 3.3 at sites (A and D) to Clean environment 7.7 at site (B) to acceptable 5.4 at site (C).

Table 3. The values of the PLI for Cu for both Species

Algae Species	Site*	PLI Value	Classification
Ulva	A	5.4	Acceptable
	B	5.3	Acceptable
	C	3.3	Moderate polluted
	D	1.2	Polluted
Enteromorpha	A	3.3	Moderate polluted
	B	7.7	Clean
	C	5.4	Acceptable
	D	3.3	Moderate polluted

*A: Al-Sabri area; B: Juliana area; C: Eshbilla area; and D: Alminah area.

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The PLI values for the Pb Table (4) showed a pollution condition at two sites (A and D) using the *Enteromorpha sp*, while for the *Ulva sp*, all the sites examined were found to range from moderately polluted at site (C) to acceptable for the other sites.

Table 4. The values of the PLI for Pb for both Specie.

Algae Species	Site*	PLI Value	Classification
Ulva	A	5.4	Acceptable
	B	5.0	Acceptable
	C	3.3	Moderate polluted
	D	5.4	Acceptable
Enteromorpha	A	1.0	Moderate polluted
	B	4.6	Clean
	C	5.8	Acceptable
	D	1.2	Moderate polluted

*A: Al-Sabri area; B: Juliana area; C: Eshbilla area; and D: Alminah area.

4. Conclusion

In conclusion, the result obtained shows that there was significant spatial variation recorded between the sites which could be attributed to the differences in the concentrations of metals in both species, thus the variation in the ability of species studied to accumulate metals. The PLI values obtained reflect the status of the environment quality and the propel impacts due to anthropogenic activity particularly the contribution from the improper discharge Although the PLI values obtained for Pb and Cu, in general, represent a low potential ecological risk, it still poses a threat to the human health and to the sensitive biological communities and also indicates the importance to monitor the coastal area on a regular basis. There was a need for more investigation and confirmation on the sources of each individual metal and to assess their risk on a long-term basis.

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