Indonesian Journal of Science & Technology

Journal homepage: http://ejournal.upi.edu/index.php/ijost/

Monitoring heavy metal contamination levels and microbiological pollution in seawater of Agadir coastal zones

Illyass Bazzi[1,2], Khadija El Mouaden[1], Aicha Chaouay[1], Abdelaziz Ait Addi[1], Mohamed Hamdani[1], Souad El Issami[1], Mustapha Hilali [1], Belkheir Hammouti[1], Khalid Abbiche[1], Rachid Salghi[2]*

[1]Chemistry Physics, Faculty of Sciences, Ibn Zohr University, Agadir, Morocco
[2]Applied Chemistry and Environment, University Ibn Zohr, Agadir, Morocco
*Correspondence: hammoutib@gmail.com

ABSTRACT

The objective of this study was to monitor the bacteriological contamination of the seawater of the marine fisheries of the coastal Agadir, Morocco. The study was focused on the diagnosis on the pollution in heavy metals, such as cadmium, lead, and mercury in five zones: the port of Imi Ouaddar fish boarding (zone Z1), the old port of Agadir (zones Z2 and Z3), the port of Agadir Marina (zone Z4), and the estuary of Oued Souss (zone Z5). The analyses were done by testing physicochemical parameters (such as pH, temperature, dissolved oxygen, salinity and conductivity) as well as microbiological and atomic adsorption analyses. The experimental results showed that the values of the physicochemical parameters were almost the same in all zones, while the microbial conditions were different, in which this is due to the existence of heavy metals. The more heavy metal concentrations affected the condition of microbes in the sea water, confirmed by the number of Escherichia coli. This study demonstrated the importance of controlling concentration of heavy metals for better sustainability of environment.

ARTICLE INFO

Article History:
Submitted/Received 12 Apr 2019
First revised 25 May 2020
Accepted 02 Jul 2020
First available online 04 Jul 2020
Publication date 01 Dec 2020

Keywords:
Heavy metals;
Agadir coastal;
seawater;
microbiological pollution, atomic adsorption.

1. INTRODUCTION

Pollution increases gradually, facing problems in the boosting population and industry (Anshar *et al.*, 2016). Millions of tons of pollutants formed by chemical releases from our industries, agriculture, and daily activities (Laasri *et al.*, 2016; Alla *et al.*, 2006). Most of the pollutants are heavy metals, fertilizers, and pesticides, as well as plastic bags that are floating on the edge of these ocean's waters..

In natural aquatic ecosystems, heavy metals are found at low concentrations, typically nanograms or micrograms per liter, while recently they have been grown rapidly (Maanan, 2008; Zeroual *et al.*, 2020). The main reason for the increases in the number of heavy metals are rapid population growth, urbanization, expansion of industrial activities, exploration and exploitation of natural resources, expansion of irrigation, and the excess usage of other modern agricultural practices. These bring direct impacts on the ecosystem, especially the number of microbiological pollution (Elmouaden *et al.*, 2015; Chahid *et al.* 2014). Microbiological contamination has important consequences for human health and marine species (flora and fauna) (Sakellariadou, 2015).

This study was to investigate bacteriological point of view, physicochemical properties, and heavy metal content in the seawater. As a model, we used the ports of Agadir and the estuary zone of Oued Souss, Morocco since this area is one of the most popular place for tourism.

2. MATERIALS AND METHODS

2.1. Sampling

The evaluation was done by monitoring the bacteriological contamination of the seawater of the marine fisheries of the coastal Agadir, Morocco. The study was focused on the diagnosis on the pollution in heavy metals, such as cadmium (Cd), lead (Pb), and mercury (Hg) in five zones: the port of Imi Ouaddar fish boarding (zone Z1), the old port of Agadir (zone Z2 and Z3), the port of Agadir Marina (zone Z4), and the estuary of Oued Souss (zone Z5). The zones are described in **Figure 1**. The collected seawater was transported in sterile polyethylene bags with closure caps that were previously washed and rinsed with seawater to the laboratory under isothermal conditions between 4 and 6°C.

The analyses were done by testing physicochemical parameters (such as pH, temperature, dissolved oxygen, salinity and conductivity) as well as microbiological and atomic adsorption analyses.

For the biological analysis, several analyses were done: identification of total coliforms (TC), fecal coliforms (CF), and confirmation to Escherichia coli species. In our study, the analysis technique used membrane filtration. In short, three volumes (i.e. 1, 10, and 100 mL) were filtered (Millipore, pore diameter of 0.45 µm) and deposited on an agar medium with Tergitol and Triphenyl Tetrazolium Chloride (TTC - Tergitol 7), which were purchased from Aldrich US. The samples were incubated at 37°C for TC and 44.5°C for FC for 24 hours (Elmouaden *et al.*, 2016).

For heavy metal analysis, one of which collected seawater was filtered through 0.45 µm Millipore filters for obtaining filtered water, and all the water samples were acidified to pH = 2 with nitric acid (PT. Multi Nitrotama Kimia (MNK), Indonesia) in order to minimize the precipitation. Subsequently, three trace metals are analyzed. Analyses of selected heavy metals were done using atomic absorption spectrophotometer (AAS, Shimadzu AA-7000, Japan). Based on different concentrations of selected heavy metals in the samples, flame spectrophotometry and graphite furnace method were used for heavy metal concentration determination for Pb and Cd. The AAS was done using a deuterium lamp at

different lengths. The unit is equipped with a graphite furnace (GFA-EX7i) using ultra-pure Argon Alpha as an inert gas. The system is driven by Wizaard software via the RS232 interface. The concentration of total Hg was determined by an AAS equipped with a specific lamp controlled by AULAWIN software. The device is equipped with a non-specific background corrector (deuterium lamp).

3. RESULTS AND DISCUSSION

3.1. Physicochemical properties of seawater

The physicochemical analyses were measured in situ in order to determine the quality of seawater collected. The values obtained for the date of June 2019 are summarized in **Figure 2**.

We observed that the pH recorded is slightly alkaline in all areas of Agadir Bay. We obtained the lowest value of 7.71 in the estuary of Oued Souss. The highest value (8.1) is recorded in Z1. The observed values revealed that the pH of the seawater is alkaline in all the studied areas. The temperature variation in function of the marine zones registered a maximum at Z4 and Z5 (28.8 and 23.5°C respectively).

Concerning the conductivity measurements, the recorded values vary between 55.0 and 55.4 mS/cm. These results are comparable to those found in previous works from the same region (Elmouaden *et al.*, 2016). The same observation could be applied for the values of salinity. It varied between a minimum of 36.5 g/L and a maximum of 38.8 g/L in all zones. The lowest value (36.1 g/L) was noted in Z4, and the highest (38.8 g/L) was found in the estuary of Oued Sous (Z5).

The value of dissolved oxygen remains the same for all the zones. This is one of the most useful parameters for water, and is an excellent indicator of its quality (pollution) (Waqas and Bilad, 2019; Nandiyanto *et al.*, 2019).

Figure 1. Sampling sites of seawater collected

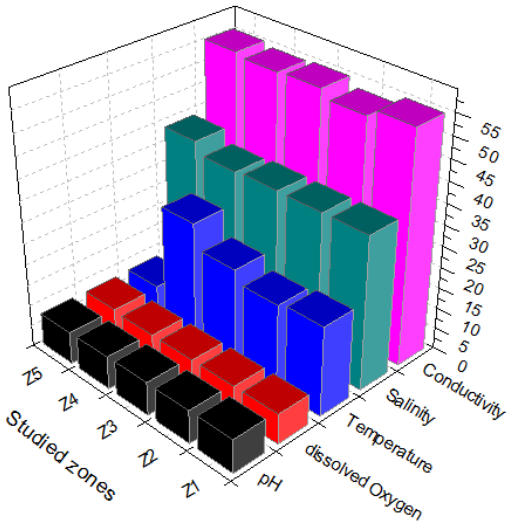

Figure 2. Physicochemical properties of the seawater of of Agadir coastal, Morocco

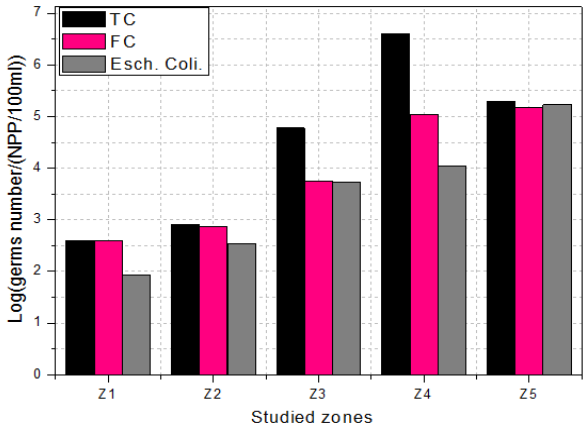

Figure 3. Evolution of the concentration of the three studied germs in seawater

3.2. Microbiological Test Results

The set of concentration average results of the concerned bacteria is shown in **Figure 3**. This figure shows the existence of an important and satisfy similarity between the evolution patterns of the average value of fecal coliforms and E. coli. From **Figure 3**, Zones 3-5 presented an important microbiological condition regarding CT, CF, and *E. coli* number. This high pollution is caused by the abundant discharges of urban wastewater. The main problems for zone 5 are due to the Oued Souss, whereas that for zone 4 are urban wastewater and the presence of tourist activity. The seawater of the port in Z3 also revealed significant total and fecal coliform charge (species that are found exclusively in compounds with an origin fecal) with a high concentration greater than 100 or even 1000 (NPP/ 100 mL). This result is probably related to the consequences of heavy releases of organic-rich industrial wastewater and chemical pollutants, liquid hydrocarbon releases and oil changes, bilge water from vessels, and the density of industrial activities in the port (Kundu and Mishra, 2018).

3.3. Evaluation of the heavy metals state of Agadir coastal

The overall results of the heavy metal analyses are presented in **Figure 4**. Based on the results obtained, we revealed the presence of the three metals in the seawater of the five sampling zones. For the Cd, zone 4 and zone 3 (Old fishing

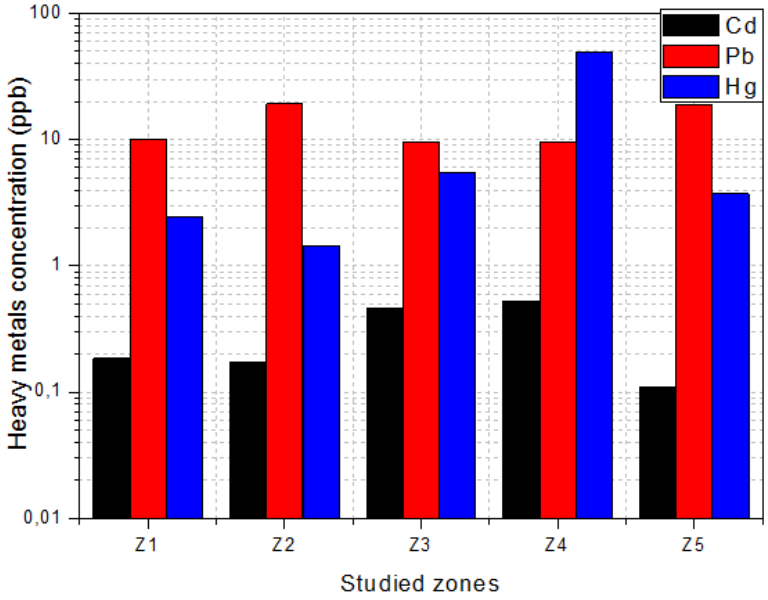

Figure 4. Concentration of Cd, Pb, and Hg in the zones

harbor on the embarkation side) noted the highest levels sequentially. The concentrations found in zones 3 and 4 led us to assuming the presence of one or more sources of pollutions in the surrounding area of the above-mentioned stations.

In addition, the presence of Cd in the environmental media is commonly related to its use in large applications, especially in batteries, in requests to protect steel against corrosion, or as a stabilizer for plastics and pigments (Weggler at al., 2004; Campbell, 2006). For the Pb metal, zone 2 (former fishing port on the fishing side) and zone 5 (Estuary Oued Souss) showed the maximum recorded values (19 and 18 ppb respectively). The elevation of Pb concentration at Zones 2 and 5 can be explained by the diffusion pollution induced by the discharges of pollutants into the basin and the significant fishing activity at this site. Moreover, the boarding of the boats during the resting period and their maintenance as well as protection against the corrosion problems increased the concentration of Pb in this area (Rees *et al.*, 2014). In the case of Hg, Zone 4 (Marina Harbor) has the highest value of 49 ppb. This unexpected pollution is probably related to the releases that may present a diversity of pollutants providing this metal in the seawater of this port (Temara *et al.*, 1997).

4. CONCLUSION

Analysis of pollutions in five zones in port in Morocco due to the diversified economic activities was done. The zones are Z1 (Port of Imi Ouaddar), Z2 (Old Port of Agadir - embarkation side) presenting boarding and fish trade activities, Z3 (Old port of Agadir-fishing side), Z4 (the port of Marina d'Agadir) as a marina intended mainly for tourist activities, and Z5 (estuary of Oued Souss) characterized by fishing activities. The results are: (1) The values of the physicochemical parameters are not so much affected by the seawater-sampling zone; (2) Detection of the pollution of all the areas by *E. coli* bacteria. Z4 is very polluted by the germs indicating a recent pollution, which is followed by zones Z5 and Z3. Zones Z1 and Z2 are less polluted; (3) The presence of the three metals in the seawater of the five sampling areas. The concentration of each metal varies from one area to another, depending on industry and population activities.

5. REFERENCES

Alla, A. A., Mouneyrac, C., Durou, C., Moukrim, A., & Pellerin, J. (2006). Tolerance and biomarkers as useful tools for assessing environmental quality in the Oued Souss estuary (Bay of Agadir, Morocco). *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *143*(1), 23-29.

Anshar, A. M., Taba, P., & Raya, I. (2016). Kinetic and Thermodynamics Studies the Adsorption of Phenol on Activated Carbon from Rice Husk Activated by ZnCl2. *Indonesian Journal of Science and Technology*, *1*(1), 47-60.

Campbell, P. G. C. (2006). Cadmium-A priority pollutant, *Environmental Chemistry, 3*(6), 387–388.

Chahid, A., Hilali, M.,Benlhachimi, A., & Bouzid, T., (2014). Contents of cadmium, mercury and lead in fish from the Atlantic sea (Morocco) determined by atomic absorption spectrometry, *Food Chemistry*, *14715*, 357-360

Elmouaden, K., Chaouay, A., Oukhrib, R., Jbara, O., Jodeh, S., Salghi, R., Hamed, O., Hilali, M., bazzi, L., Hammouti, B., & Radi, S., (2015). Microbiological Pollution of Marine Environment of the Coastal of Agadir. Impact on the Corrosion of Mild Steel. *International Journal of Electrochemical Science*, *10*, 7955 – 7965

Elmouaden, K., Jodeh, S., Chaouay, A., Oukhrib, R., Salghi, R., Bazzi, L., & Hilali, M., (2016). Sulfate-Reducing Bacteria Impact on Copper Corrosion Behavior in Natural Seawater Environment. *Journal of Surface Engineered Materials and Advanced Technology*, *6*, 36-46.

Kundu, P., & Mishra, I. M., (2017). Treatment and reclamation of hydrocarbon-bearing oily wastewater as a hazardous pollutant by different processes and technologies: a state-of-the-art review, *Review in Chemical Engineering*, *35*(1), 73-108

Laasri, A., Et-taleb, S., Morad, Y., Hilali, M., & Benlhachemi, A., (2016). Physico-chemical study of marine waters sands in the region of Sidi Ifni: particle size and determination of the concentration of heavy metals, *Journal of Materials and Environmental Science*, *7*(12), 4778-4785

Maanan, M., (2008). Heavy metal concentrations in marine molluscs from the Moroccan coastal region, *Environmental Pollution*, *153*, 176-183

Nandiyanto, A. B. D., Sukmafitri, A., Ragadhita, R., Oktiani, R., Haristiani, N., & Hamidah, I. (2019). Conventional filter for the water treatment system in rural area. *Journal of Engineering Science and Technology*, *14*(4), 2090-2097.

Rees A.B., Turner A., & Comber, S. (2014). Metal contamination of sediment by paint peeling from abandoned boats, with particular reference to lead*, The Science of the Total Environment, 494*, 313-319

Sakellariadou, F., (2015). Maritime pollutants in shipping and commercial European ports based on relevant physical and biogeochemical environmental parameters (IUPAC Technical Report), *Pure and Applied Chemistry, 87*(11-12), 1151–1166

Temara, A., Warnau, M., Jangoux, M., & Dubois, P. (1997). Factors influencing the concentrations of heavy metals in the asteroid Asterias rubens L.(Echinodermata). *Science of the total environment*, *203*(1), 51-63.

Waqas, S., & Bilad, M. R. (2019). A review on rotating biological contactors. *Indonesian Journal of Science and Technology*, *4*(2), 241-256.

Weggler, K., McLaughlin, M. J., & Graham, R. D., (2004). Effect of Chloride in Soil Solution on the Plant Availability of Biosolid-Borne Cadmium, *Journal of Environmental Quality*, *33*(2), 496–504.

Zeroual, S., El Bakkal, S.E., Mansori, M., Lhernould, S. Faugeron-Girard, C., El Kaoua, M., & Zehhar N., (2020). Cell wall thickening in two Ulva species in response to heavy metal marine pollution, *Regional Studies in Marine Science, 35*, 101-125.