Environmental Engineering and Management Journal February 2015, Vol.14, No. 2, 331-340
http://omicron.ch.tuiasi.ro/EEMJ/

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ENVIRONMENTAL IMPACT AND RISK ASSESSMENT OF THE MAIN POLLUTION SOURCES FROM THE ROMANIAN BLACK SEA COAST

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Abstract

The environmental impact assessment (EIA) is a compulsory evaluation instrument for environmental management and decision making processes and applies to different phases of activities (plans, programmes, projects and /or existing production or services), because it measures the natural and anthropogenic activities effects upon the environment. These impacts may affect the cultural richness, biodiversity, social-economic conditions and human health as well as the ecosystem equilibrium.
The aim of this study was to evaluate the environmental impact generated by the heavy metal pollution from the main sources located in the southern area of the Romanian Black Sea coast. Various pollution sources that discharge contaminated effluents were considered for the impact and risk assessment with concern to water and sediments. The main sources analyzed were the effluents of wastewater treatment plants (4 treatment plants of SC RAJA Constanta) and the effluents of a refinery. The methods applied in order to assess the impact of pollution sources with heavy metals were *Rapid Impact Assessment Matrix* (RIAM) and *Integrated Environmental Impact and Risk* approach.
Environmental indicators used for impact quantification were correlated considering the concentrations of heavy metals from the effluents (generated by the 5 pollution sources), marine water and sediments.
The results obtained in this study provide a general image for the heavy metal pollution caused by considered anthropogenic activities on the Romanian Black Sea Coast. The results showed that the analyzed pollution sources do not have a significant negative impact generated by the heavy metal pollution. However, the presence of other pollution sources should not be overlooked because the ecosystem equilibrium must be maintained even if the concentrations of the heavy metals are below the maximum allowed values.

Key words: Black Sea, heavy metals, impact assessment, pollution sources, risk assessment

Received: November, 2014; Revised final: February, 2015; Accepted: February, 2015

1. Introduction

Environmental Impact Assessment (EIA) is usually defined as a mandatory assessment procedure that analyzes and evaluates the impacts that human activities can have on the environment (Toro et al., 2013). The environmental impact assessment is defined by the International Association of Impact Assessment (IAIA) as the "identification, estimation, evaluation and mitigating of the significant effects of the development projects" (Mondal et al., 2010). EIA uses several types of instruments and applies to different phases of activities (projects and /or existing production and services processes), may be applied on a local, national or international scale and has as main deliverable a form of Environmental Impact

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Statement (EIS) (UNEP, 2002). The environmental impact evaluation relies on both qualitative and quantitative impact evaluation methods that are being used to assign (qualitatively) or compute (quantitatively) numerical values for the environmental impacts (Gavrilescu, 2007; Burger, 2008; Buytaert et al., 2011; Singh et al., 2012).

The international protocols emphasize that one should not act or authorize anthropogenic activities without a serious analysis of the possible negative effects produced to the environment. In some agreements it is mentioned that the environmental impact and risk assessments are working together only. Comprehensive assessments, usually link environmental impact assessment (EIA) with risk assessment (RA) so as to help decision-making processes in water resources management (Teodosiu et al., 2015). Traditionally, risk assessment (RA) refers only to human health (originally referred to occupational health, then public health and safety) but recently it was extended to the environmental level, including freshwater and marine ecosystems (Kiss and Shelton, 2007; Lexer et al., 2006).

In the environmental impact assessment, simple qualitative methods can be easily applied, by working with criteria capable to identify and evaluate the likely environmental changes caused by specific activities such as projects. More than that, the affected community must be informed and invited to debates before the decision making process regarding the project implementation is accomplished.

Toro et al. (2013) have analyzed the limitations of the qualitative environmental impact assessment methods with the purpose to reduce the uncertainties and subjectivity in the assessments regarding the impact importance. Thus, they propose to calculate the *total importance of the impact* (*ImpTotal*) by ponderating the *project importance* (*ImpPro*), the *importance of the activity that generates the impacts* (*ImpAct*), as well as the *importance of the vulnerability of the environmental factors* (ImpVul). This proposal has the advantage of calculating the total impact, based on a wider range of information.

The method of Rapid Impact Assessment Matrix (RIAM) is often used in the environmental impact quantification of projects or new activities. Kuitunen et al. (2008) conducted a study that focused on the comparison of results generated by RIAM applied for new projects or activities within EIA process and the results generated within Strategic Environmental Assessment (SEA).

The results are comparable and reliable for both situations thus the method proved to be an objective one. Also, Ijas et al. (2010) applied the RIAM method for projects/new activities, quantifying the positive and negative impact, while other authors such as Mondal et al. (2010) quantified the environmental impact assessment of different municipal solid wastes from Varanasi India, and Upham and Smith (2013) quantified the environmental impact (positive or negative) in the case of biofuel energy production considering the European Commission recommendations for renewable resources.

The main problems in aquatic environments are caused by the pollution generated by human activities due to industries, agriculture, social development, transportation, mining, etc. and their solving requires integrated approaches based on the water use cycle concept (Teodosiu et al., 2012).

This can damage the entire representative life forms of the ecosystems. The pollution sources should be carefully identified and effective preventive pollution methodologies should be applied along with end-of-pipe treatment processes. The heavy metals are an important category of the priority pollutants that contaminate the aquatic environment and may be generated by wastewaters from the mining, metallurgic, chemical industries as well as from natural sources. They are toxic elements for all life forms and accumulate very fast in the body mass of the marine organisms (Jitar et al., 2012). According to Iordache (2009), the sediments represent the final reservoir of most toxic heavy metals generated by different pollution sources.

The aim of this study was to evaluate the environmental impact generated by the heavy metal pollution from the main sources located in the southern area of the Romanian Black Sea coast. Various pollution sources that discharge contaminated effluents were considered for the impact and risk assessment with concern to water and sediments.

The environmental indicators used for impact quantification were correlated considering the concentrations of heavy metals from the effluents (generated by 5 pollution sources), marine water and sediments. The results obtained from this study provide a general image for the heavy metal pollution caused by considered anthropogenic activities on the Romanian Black Sea Coast.

2. Methodology

2.1. Study area description

The heavy metal pollution of the Black Sea is a multinational problem caused by the anthropogenic activities conducted near the seashore areas and rivers that flow into the sea. It is important to identify each pollution source but it is quite difficult to provide an inventory of *point* and *non-point* pollution sources, due to the numerous and various activities and trans-border discharges.

The natural background concentrations of heavy metals are unknown in many areas of the Black Sea and it is hard to quantify the real ones. The following working strategy was used to achieve the objectives of this study, as presented in Table 1.

The monitoring studies conducted by the National Institute for Marine Research and Development (NIMRD) "*Grigore Antipa*" Constanta, Romania noticed that the heavy metals concentrations compared with the maximum values provided by the international regulations represent a risk in the sea water from the shore area.

According to the official information sources provided by the national monitoring program of the Black Sea (NIMRD "*Grigore Antipa*" and Administratia Bazinala de Apa Dobrogea-Litoral-ABADL) the main sources of heavy metal pollution for the Romanian Black Sea sector are: the Danube River through its pollution loads; local pollution sources from the Romanian shore area; pollution sources located in the Ukrainian Black Sea sector.

The main anthropogenic pollution sources identified for the Romanian coast were: the wastewater treatment plants, the oil refinery, the harbor and the ship construction sites. The agricultural activities were excluded from the main sources of pollution with heavy metals because their influence is not significant. The data were extracted from the official reports published by NIMRD "*Grigore Antipa*" (INCDM, 2010, 2011, 2012) and Administratia Bazinala de Apa Dobrogea-Litoral (ABADL) available for the years 2010, 2011 and 2012. The main anthropogenic pollution sources are presented in Fig. 1. Jitar et al. (2014), while the associated activities are depicted in Table 2.

2.2. Environmental impact quantification - methods description

Two matrices were applied for the impact and risk quantification induced by the heavy metals (Ni, Cu, Cd, Pb, Cr) on the Romanian Black Sea ecosystem: the Rapid Impact Assessment Matrix (RIAM) and the Integrated Quantification of Impact and Risk matrix (SAB) (Robu and Macoveanu, 2010; Teodosiu et al., 2013). The RIAM method was developed by Cristopher Pastakia to quantify the environmental impact (Pastakia, 1998; Pastakia and Jensen, 1998). Since then, it has been tested in many studies for environmental impact assessment (Ijas et al., 2010; Kuitunen et al., 2008; Robu et al., 2007; Suditu and Robu, 2012). RIAM uses specific criteria in quantification the environmental impact, as follows:

a) criteria that can individually modify the obtained score (group A), and

b) criteria that cannot individually modify the obtained score (group B).

Each group of criteria (A and B) is calculated considering the specific Eqs. (1) – (2). The Environmental Score (ES) is calculated as the value resulted by multiplying the grades from *group A* with the sum of grades from *group B* (Eqs. 1-3) (Kuitunen et al., 2008; Suditu and Robu, 2012), where: (A_1), (A_2) are the values assigned to individual criteria from group A; (B_1), (B_2), (B_3) are the values assigned to individual criteria from group B; *AT* is the result of multiplying all *A* grades; *BT* is the result of summing all B grades; ES is the environment score of the environmental assessed components (in this case water and sediments).

$$(A_1)\cdot(A_2) = AT \tag{1}$$

$$(B_1)+(B_2)+(B_3) = BT \tag{2}$$

$$(AT)\cdot(BT) = ES \tag{3}$$

It was assumed that for the assessed sources of pollution, there is a negative influence on the environmental quality. Thus, for the magnitude of the change / effect, values between 0 and (-3) are assigned (Table 3). In order to assure an evaluation system with more certainty, the environmental scores (ES) are classified so that a comparison of quantified impacts for various situations can be done (Table 4).

The second method applied was the Integrated Quantification of Impact and Risk that was performed based on a specific algorithm developed in previous studies (Robu, 2012; Stefanescu et al., 2011; Suditu and Robu, 2012; Teodosiu et al., 2013).

According to these studies, the integrated method may be applied for four environmental components: surface water, ground water, air and soil. The environmental impact quantification is based on two parameters: the *magnitude* of the impact/effect which depends on the measured pollutant concentration in the environment and the *importance* of environmental component that takes values between 0 and 1 (1 representing the most important component - *maximum importance*) (Robu and Macoveanu, 2005; Robu et al., 2005).

In this study there were considered two environmental components: seawater and sediments. The environmental impact (*EI*) was quantified based on Eqs. (4, 5), where: *Q* is the quality of the environmental component; *UI* is the unit of importance for each environmental component; *MAC* is the maximum admitted concentration for each component according to the environmental standards; C_{det} is the measured concentration in the samples.

$$EI = \frac{UI}{Q} \tag{4}$$

$$Q = \frac{MAC}{c_{\text{det}}} \tag{5}$$

The environmental risk was calculated based on Eq. (6), where: *EI* is the environmental impact; *P* is the probability of impact occurrence with values between 0 and 1.

$$ER = EI \times P \tag{6}$$

One should notice that if the impact, namely the environmental risk, has a low value, this denotes that the environmental impact is considered to be insignificant and the associated risk is negligible. As a result, the higher the values, the higher the impact risks are.

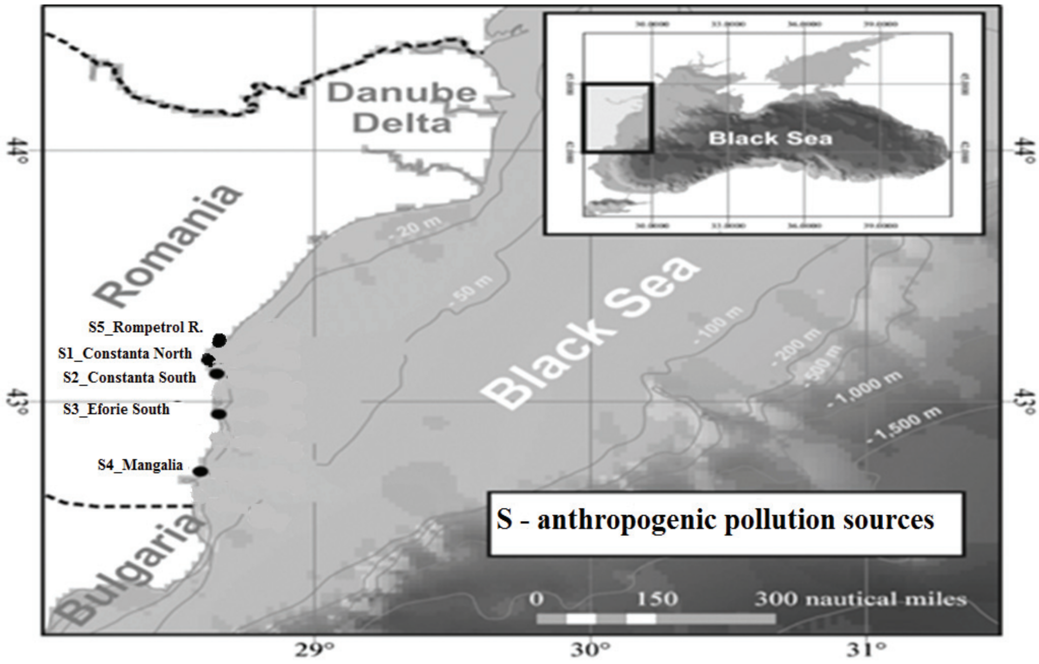


Fig. 1. Anthropogenic sources of pollution with heavy metals identified on the Romanian Black Sea coast

Table 1. The working strategy for the environmental impact and risk quantification

Aim of this study	*Objectives*	*Specific activities (A)*
Assessment of the environmental impact and risk generated by the heavy metals pollution	O1: Identification of the main pollution sources (natural and anthropogenic) from the Romanian Black Sea shore	A1: Analysis of the national monitoring programs and inventory of the main pollution sources from the Romanian Black Sea shore
	O2: Identification of the main polluting agents	A2: Data collection from the annual reports databases; A3: Selection of the environmental quality indicators proposed–heavy metals concentrations
	O3: Impact and risk assessment induced by the considered pollution sources on the sea water and sediments	A4: Selection of two assessment matrices for environmental impact and risk caused by the selected indicators; A5: Analyses and processing of collected raw data and elaboration of the evaluation matrices A6: Quantification of the impact and risk induced by the heavy metals in the marine environment

Table 2. The main anthropogenic sources of pollution with heavy metals and the associated activities

Pollution sources	*Activities*
S_1_Wastewater treatment plant Constanta North	This wastewater treatment plant is managed by S.C. Raja S.A. Constanta and collects the wastewater from the Northern district of Constanta town and Mamaia resort.
S_2_Wastewater treatment plant Constanta South and the Constanta Harbor area	This wastewater treatment plant is managed by S.C. Raja S.A. Constanta and collects the wastewater and industrial water from the Constanta town and harbor area. The water is mechanically and biologically treated and then discharged in the harbor area of the Black Sea.
S_3_Wastewater treatment plant Eforie South	This wastewater treatment plant is managed by S.C. Raja S.A. Constanta and collects the wastewater from Eforie Sud and Eforie Nord resorts, Costinesti resort, Schitu, Agigea and Techirghiol localities.
S_4_Wastewater treatment plant Mangalia and the Mangalia Harbor area	This wastewater treatment plant is managed by S.C. Raja S.A. Constanta and collects the wastewater from Mangalia town, and the following resorts: Olimp, Neptun, Jupiter, Venus, Aurora and Saturn.
S_5_Rompetrol Refinery	This oil refinery is managed by S.C. Rompetrol Rafinare S.A. Navodari. It is a new chemical oil refinery unit that processes the imported oil.

Table 3. Description of criteria (conventional) (Kuitunen et al., 2008)

Criterion	*Scale*	*Description*
A_1 - The importance of the condition	4	Important for the national/international interests
	3	Important for the regional/national interests
	2	Important only for the zones found near the local zone
	1	Important only for the local condition
	0	No importance
A_2 - The magnitude of the changing/effect	+3	Major importance benefit
	+2	Meaningful benefit of the quo status
	+1	Benefit of the quo status
	0	Lack of change/status quo / no influence
	-1	Negative change of quo status
	-2	Significant disadvantages or negative changes
	-3	Major disadvantages or changes
B_1 - Permanence	1	No changes
	2	Temporary
	3	Permanence
B_2 - Reversibility	1	No changes
	2	Reversible
	3	Irreversible
B_3 - Cumulatively	1	No changes
	2	Non-cumulative/unique
	3	Cumulative/synergetic

Table 4. Description of the environmental scores calculated (ES)

Environmental score	*Class*	*Description of the category*
+72 to +108	+E	Major positive changes/ impact
+36 to +71	+D	Significant positive changes/ impact
+19 to +35	+C	Moderate positive changes/ impact
+10 to +18	+B	Positive changes/ impact
+1 to +9	+A	Slight positive changes/ impact
0	N	Lack of change/status quo/ no impact
-1 to -9	-A	Slight negative changes / impact
-10 to -18	-B	Negative changes / impact
-19 to -35	-C	Moderate negative changes / impact
-36 to -71	-D	Significant negative changes / impact
-72 to -108	-E	Major negative changes / impact

The algorithm of the environmental impact and risk quantification was developed in the Excel program so that it can easily be used and applied under various circumstances (Robu et al., 2007; Stefanescu et al., 2012).

3. Results and discussions

3.1. Rapid Impact Assessment Matrix results

The impact assessment performed by using RIAM method showed that pollution sources (S_1-S_5) (Table 5) have a slight negative impact leading to insignificant negative changes (ES $_{total}$ belongs to category A: *Changes/slight negative impact*), all concentrations of the analyzed pollutants being below the MAC limits according to NTPA 001/2005 (GD 188, 2002; GD 352, 2005).

RIAM method was applied to the average of annual measured concentrations of heavy metals in water and sediment. This data was published in the journal of Marine Research, under the coordination of the "*Grigore Antipa*" National Institute for Marine Research and Development Constanta. Determination of the heavy metals concentrations in 2010, 2011 and 2012 was made within a monitoring program by analyzing *seawater* samples (surface horizon of shallow sediments) and *biota* from transitional areas (Sulina – Portita, 5 - 20 m), coastal (Gura Buhaz, Constanţa East, Casino Mamaia, Constanţa North, Constanţa South, Eforie, Mangalia, Vama Veche, 0 – 20 m) and *marine* (depths exceeding 20 m) (*Report on the status of marine and coastal environment* in 2010/2011/2012). According to environmental reports, in all these three years (2010-2012), the concentration values determined in relation with the environmental quality standards for water (Order 161/2006; Directive 2008/105/2008) were below the MAC limits (maximum allowed concentrations), only part of the measurements exceeding MAC. Higher values of Cu were found in the port area and treatment plants. Cu and Pb showed a slight increase in 2011, contrary to the lowered levels of cadmium.

Usually high concentrations of heavy metals are recorded in sediments from areas under anthropogenic impact: ports and wastewater treatment plants. The average concentrations calculated for the coastal zone (0 – 20 m) did not exceed MAC, but in the sediments from transitional and marine areas were registered average values of Cu, Cd and Ni which exceeded MAC. Close to the Danube River, treatment plants and harbors, all concentrations of heavy metals in sediments were above MAC. Taking into account these aspects, marks for the impact assessment according to RIAM method were awarded. According to these results for the environmental component *water* in 2010 resulted a negative impact, a moderate negative impact in 2011, noting an improvement in 2012 when, as evaluated, water status (ES) showed a slight negative impact (Figs. 2 and 3).

The environmental component *sediment* showed a significant negative impact in 2010, a major negative impact in 2011, while the final values of the average scores still showed an improvement in 2012, as presented in Fig. 2.

3.2. Integrated impact and risk assessment results

The application of the integrated impact and risk assessment method (SAB) for the point sources of pollution (S_1-S_5), considering the same database as for the RIAM method, led to the same result, namely both the environmental impacts and environmental risks were below the score of 100, which means that the environment is not affected by the activities performed at the sources and the environmental risk is insignificant (Fig. 4).

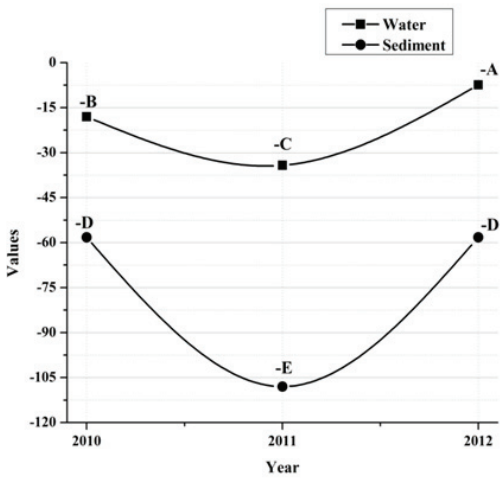
Although the wastewater treatment plants as a whole do not have a significant impact upon the environment (Fig. 4), it was observed that S_3 had a higher score of environmental impact and risk in 2010 and 2011 (Figs. 5a. and 5b.). This can be explained by the fact that the plant was the subject of rehabilitation works (for two years) in order to introduce the tertiary treatment stages that was completed in 2013.

The results of the environmental impact and risk assessment (by SAB) induced by heavy metal pollution in water and sediments from the Romanian Black Sea coast revealed that the environmental component "*water*" received the importance grade 1 and probability of impact occurrence of 0.5, while "*sediments*" 0.85 for importance and 0.85 for probability. The integrated method applied for the same quality indicators in 2010 showed an environmental impact due to the effects of anthropogenic activities within allowable limits for water; for sediments, the environmental impact suggested an environment severely affected by human activities.

The environmental risk was negligible for water, with an unacceptable risk for sediments. In 2011 the environmental impact increased both for water and sediment, indicating an impact due to human activities causing discomforts to the environment (Fig. 6). For sediments a major risk was quantified, being necessary measures of prevention, control and remediation. This may be explained by the floods from 2010 that had a significant contribution to the pollution in the Danube River basin, in particular, and reflected in the sediments that accumulated heavy metals.

According to the same method (SAB) applied in 2012 for water, the impact values were 100- 350 which suggests that the environment is subject to the effects of human activities within acceptable limits while the environmental risk is negligible (values less than 100) (Fig. 6). For sediments, the impact showed an environment affected by human activities, causing disturbance for different forms of life (values of 500-700), while the calculated risk is like in 2010 (unacceptable environmental risk, being necessary measures of prevention and control).

The impact and environmental risk assessment considering heavy metals as priority pollutants was performed in order to observe the current state of the marine ecosystem. By using the applied matrices, we highlighted the fact that the point sources of pollution (S_1-S_5) identified on the mainland do not have a significant contribution to heavy metal pollution of water and sediments.



ES_{water}2010: **-18** (Changes/negative impact, -B)
ES_{water}2011: **-34.2** (Changes/moderate negative impact, -C)
ES_{water}2012: **-7.4** (Changes/slight negative impact -A)
$ES_{sediments}$2010: **-58.2** (Changes/significant negative impact, -D)
$ES_{sediments}$2011: **-108**(Changes/major negative impact, -E)
$ES_{sediments}$2012: **-58.2** (Changes/significant negative impact, -D)

Fig. 2. Environmental scores (ES) for water and sediments from the Romanian Black Sea shore in the years 2010-2012, according to RIAM method

Table 5. The matrix of environmental impact induced by assessed point pollution sources (environmental component *water*)

Pollution source	Year	Quality indicator (i)	A_1	A_2	B_1	B_2	B_3	ES_i	ES_{year}	ES
S_1	2010	Cd	1	-2	2	1	1	-8	-8.6	-6.67
		Cr	1	-2	2	2	1	-10		
		Ni	1	-2	2	2	1	-10		
		Pb	1	-2	2	2	2	-12		
		Zn	1	-1	1	1	1	-3		
	2011	Cd	1	-1	1	1	1	-3	-4.8	
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-2	2	2	2	-12		
	2012	Cd	1	-1	1	1	1	-3	-6.6	
		Cr	1	-2	2	2	2	-12		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-2	2	2	2	-12		
S_2	2010	Cd	1	-1	1	1	1	-3	-3	-4.05
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-1	1	1	1	-3		
	2011	Cd	1	-1	1	1	1	-3	-3	
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-1	1	1	1	-3		
	2012	Cd	1	-2	2	2	2	-12	-6.17	
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-2	2	2	2	-12		
		Fe	1	-1	1	1	2	-4		
S_3	2010	Cr	1	-1	1	1	1	-3	-3.75	-3.64
		Cu	1	-1	1	1	1	-3		
		Zn	1	-1	1	1	1	-3		
		Fe	1	-2	1	1	1	-6		
	2011	Cd	1	-1	1	1	1	-3	-3	
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-1	1	1	1	-3		
		Fe	1	-1	1	1	1	-3		
	2012	Cd	1	-1	1	1	1	-3	-4.17	
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-2	2	2	1	-10		
		Fe	1	-1	1	1	1	-3		
S_4	2010	Cd	1	-1	1	1	1	-3	-3	-4.67
		Cr	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-1	1	1	1	-3		
	2011	Cd	1	-1	1	1	1	-3	-4.8	
		Cr	1	-2	2	2	2	-12		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-1	1	1	1	-3		
	2012	Cd	1	-1	1	1	1	-3	-6.2	
		Cr	1	-2	2	2	2	-12		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-1	1	1	1	-3		
		Zn	1	-2	2	2	1	-10		
S_5	2010	Cd	1	-1	1	1	1	-3	-5.25	-6.37
		Hg	1	-1	1	1	1	-3		
		Ni	1	-1	1	1	1	-3		
		Pb	1	-2	2	2	2	-12		
	2011	Hg	1	-2	2	2	2	-12	-7.5	
		Ni	1	-2	2	2	2	-12		
		Pb	1	-1	1	1	1	-3		
		Fe	1	-1	1	1	1	-3		

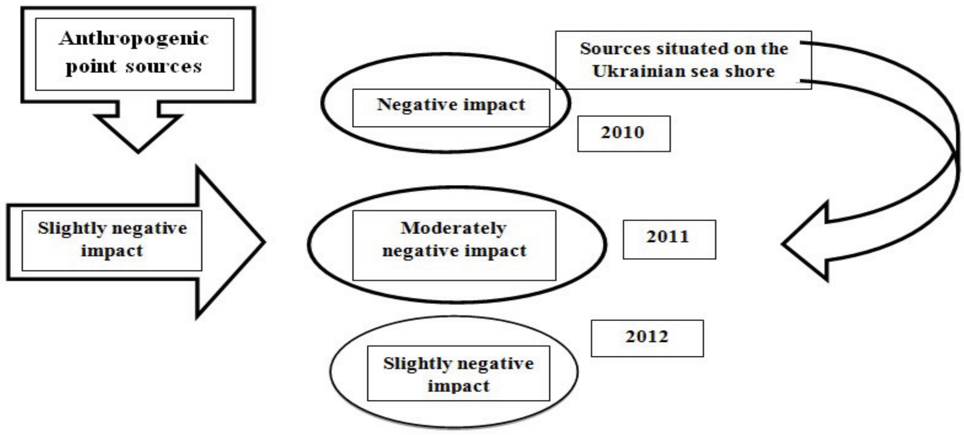


Fig. 3. Graphical representation of environmental impacts induced to water (RIAM method, 2010-2012)

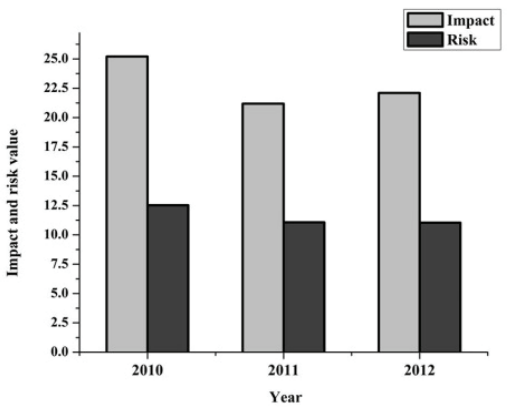
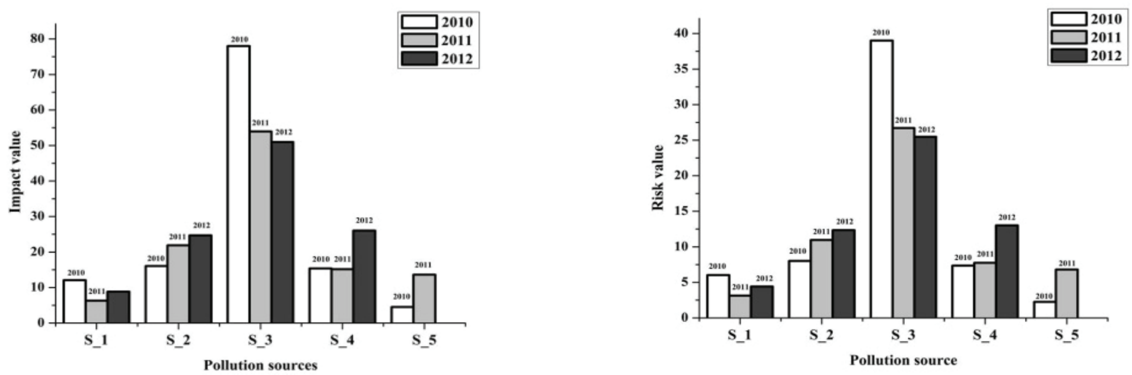


Fig. 4. Graphical representation of the results of the impact assessment and environmental risk by SAB method for the years 2010-2012 for all pollution sources (S1, S2, S3, S4, S5)



a) b)

Fig. 5. Graphical representation of the results for: a) *impact assessment* and b) *environmental risk* by SAB method for point sources

4. Conclusions

This study was focused on the assessment of the environmental impact and risk on water and sediments, due to heavy metals pollution generated by five point pollution sources of the Romanian Black Sea (S1-S5). This is the first study that analyze and quantifies the integrated impacts and risks caused by heavy metals in the marine environment through the contribution of each pollution sources based on the monitored quality indicators reported by ABADL and NIMRD institutions, Constanta. To achieve the main goal of this study, two methods were considered for assessing the impact, Rapid Impact Assessment Matrix (RIAM) and the Integrated Quantification of Impact and Risk matrix (SAB).

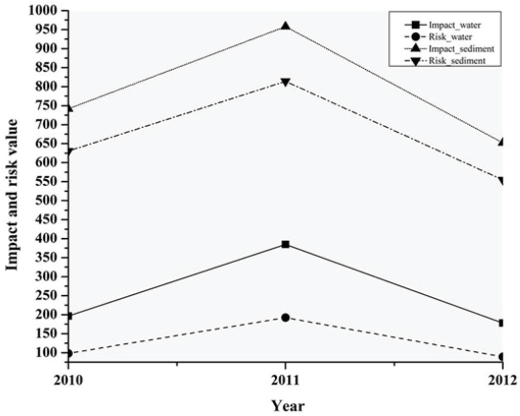


Fig. 6. Graphical representation of the results of environmental impact and risk assessment (SAB method) calculated for environmental components: water and sediment

According to these methods, the point pollution sources (S_1-S_5) taken into account for the evaluation of the environmental impact and risk do not have a major contribution in terms of heavy metal pollution in the marine environment. Although the wastewater treatment plants do not have significant environmental impacts, it could be observed that S_3 wastewater treatment plant had higher scores for environmental impact and risk in 2010 and 2011, this plant being the subject of rehabilitation works for 2 years.

The results of RIAM method for the environmental component water indicated a negative impact in 2010, a moderate negative impact in 2011 and a noticeable improvement in 2012 when, according to the assessment, the water status (ES) showed a slight negative impact.

By applying the SAB method, in 2010 resulted a significant negative impact for the environmental component "sediments", the final environmental scores (ES) indicating an improvement for 2012. The SAB method confirmed the results of RIAM method. A significant negative impact due to higher concentrations of heavy metals was observed for sediments, fact which may affect not only benthic organisms, but also the pelagic ones due to the particles re-suspension in the water column. According to the environmental reports there were high concentrations in the sediments from areas under anthropogenic impacts such as harbors and wastewater treatment plants: Constanta South and Mangalia (NRIMD, 2012a; 2012b).

Other sources of pollution of the Black Sea water and sediments should be considered as well. The heavy metals concentrations should not be neglected if the balance of the ecosystem is to be preserved, even if some recorded concentrations were below the MAC levels according to national environmental standards (MO, 2006).

Acknowledgments

This work was supported by a grant of the Romanian National Authority for Scientific Research, CNDI–UEFISCDI, project no. 60/2012, "*Integrated System for Reducing Environmental and Human-related Impacts and Risks in the Water Use Cycle*" (WATUSER).

The support of the strategic grant POSDRU/159/1.5/S/133652, co-financed by the European Social Fund within the Sectorial Operational Program Human Resources Development 2007-2013 is also acknowledged.

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