A PRELIMINARY SOIL IMPACT ASSESSMENT OF SOME ECONOMIC ACTIVITIES INTO AN URBAN SITE

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Abstract

A growing public concern about the environmental impact owning to industrial/economic development and population expansion is pointing out in recent decades. In order to assess the environmental impact into a Romanian urban site released by some economic activities, especially against the environment component: soil, there were analysed some soil samples collected from different points from the studied area. Following some complex physico-chemical analysis of some specific indicators of soil quality, it was evaluated the level of soil pollution generated by all economic activities and also their impact on soil functions. The environmental impact assessment (EIA) into the studied urban site is assessed by using the alternative method of global pollution index (I^*_{PG}). The experimental results correspond to the situation of 'environment modified by economic activities generating discomfort effects and risks for health of life forms coexisting onto soil site'. In this context, the urban site must be monitoring in order to prevent supplementary environmental pollution, and control risk pollution.

Keywords: environmental impact assessment, global pollution index, soil, urban site.

INTRODUCTION

The economic activity has increased to the point that man's relationship with the natural environment is radically altered [1]. Also, it is a major scientific uncertainty concerning the conditions under which the continuity can be assured in economic areas/systems and natural or urban environment.

Some major changes in land use are anticipating in Europe in the decades to come as a result of technological, socio-economical and political developments as well as global environmental change [2].

The industrial manufacturing and the use of synthetic products (e.g., paints, batteries, industrial waste, pesticides, industrial and agricultural sludge, etc.) can result in contamination of urban and agricultural soils.

Urban soils are known to have peculiar characteristics such as unpredictable layering, poor structure, and high concentrations of trace elements [3]. They are the 'recipient' of a large amounts of contaminants (i.e. heavy metals, dangerous organic compounds, etc.) from a variety of sources including industrial wastes, vehicle emissions, coal burning waste, and other industrial or economic activities. Urban soils had a lot of important functions, but soils can also be multifunctional by performing many services at the same time (e.g., growing crops and food/biomass production while storing/ filtering/ buffering pollutants or transforming of minerals, organic matter, water and energy, and diverse chemical substances; habitat and gene pool; physical and cultural environment for mankind; source of raw materials etc.) [4]. Different activities place different pressures on the soil and cause different impacts. The heterogeneity of soils, the wide range of functions and services they perform and the variety and combination of pressures placed upon them all require much attention [5]. Generally, soils are poorly understood when compared with other environmental media. They vary enormously

in their chemical and physical constitution and, as a consequence, their ability to perform functions [5-6].

The environmental impact of an industrial productive activity constitutes the first step in the overall assessment of the sustainability of the productive process [7]. Environmental impact assessment (EIA) is considered to be a potential multidisciplinary, objective decision-making tool that helps the company management staff, planners and politicians to choose the routes of selection, functioning and development of process technology, industrial or urban sites as well as project sites. The EIA method relies on indicators serving as criteria to evaluate whether the objectives have been attained. These indicators take account of local impacts such as noise, odour, aesthetic effects, stress on vegetable and animal life forms, regional impacts such as eutrophication, low agricultural production, or global impacts like greenhouse effects, climate changes [8-9].

The analysis of the interactions between industrial/economic activities into the studied urban site is indispensable at this scale of analysis. Indicators based on the environ-mental effects of industrial activities will take precedence over those based on practices themselves. Some scenarios must be predicted describing how the properties of soil might change, the causes of those changes and what the consequences may be in terms of soil functional ability and other potential environmental impacts. Each scenario must have three core components: (1) activities, including both anthropogenic activities and environmental parameters or processes that influence soil (e.g., cropping or climate, industrial activities), (2) soil properties, that characterise the soil for scenario and describe how it might change (e.g. organic matter, pH and bulk density), and (3) soil functions, that are performed by soils and/or impacts that arise [5].

This paper will describe a well-known Romanian EIA methodology (i.e. global pollution index) that involves the collection of baseline data on soil, noise, technological, biological, and socioeconomic components of the environment on and around the investigated urban site, identification of potential impacts, prediction of significant impacts, and evaluation of impacts on a commensurate evaluation scale [10-11].

EXPERIMENTAL

Location of the investigated urban site

The investigated urban site is situated into an important Northern-Eastern town of Romania (i.e. SV part of town with ca 320000 inhabitants and 130 economic units and institutes), into a residential/commercial area placed near an railway route and international terrestrial traffic route. The total surface of the investigated site emplacement is of ca 5.5 ha.

There are various potential pollution sources in this urban site (i.e. a commercial centre sector – S_1, a Peco storage sector – S_2, railway transport traffic sector – S_3, an old 'no functioning' cigarette plant sector – S_4 and other domestic activities). Noise levels, in general, are well within the standards, except along the road and railway route lines due to traffic, and people noise due to shopping.

The average annual temperature is around 8°-9.5°C with maximum and minimum values recorded into the summer or winter months. Total annual rainfall in the region is about 500-600 mm. No major river flows through the region.

Data collection and analyses

The soil analysis was performed using international standardized analysis methods and specific reagents according with the national environmental legislation [12-14].

Sampling and analyses of the potential pollution generated by the economic and domestic activities into the investigated urban site were made in accordance with the indi-cations of local environmental agency (i.e. analyses of some quality indicators for soil, twice times per year, and their maximum admissible limits – M.A.C.) and performed with an authorized environmental analysis laboratory.

The principal physicochemical laboratory analysis was made for specific soil indicators (e.g., actual pH, total nitrogen, total phospho-rus, total gases/vapours content, total organic carbon (TOC), total extractible compounds into petroleum ether and/or total oil compounds, total soluble salts content (TSSC), exchangeable calcium content, some heavy metals content).

EIA alternative methodology of the global pollution index (I^*_{PG})

The potential soil pollution sources on the studied urban site were identified to be mainly from four different economic and commercial sectors coexisting now and with 'limited functioning' in the present as: commercial activities, storage of different petroleum products, terrestrial railway and automobile traffic, and other activities into a 'no functioning' cigarette plant.

The values of some physicochemical indicators of soil quality were used to calculate an index to express the quality of *soil component*, EQ_i (Eq. 1) [7, 15]:

$$EQ_i = C_{i,measured} / MAC_i \quad (1)$$

where, $C_{i,measured}$ is the experimental value of analysed compound concentration, and MAC_i is the maximum admissible concentration of the analysed compound according with the national environmental legislation [14-16].

The synergetic action of potential contaminants into *soil* is expressing by the average arithmetic value for all index to express the quality of soil (i.e. EQ_{soil}).

For quantification of global pollution of environment (i.e. soil component) into the investigated site, the global pollution index (I^*_{PG}) is used by the alternative methodology (concentric circles graphical methodology) [17]. The calculation of global pollution index is done as in Eq. (2) [18-19].

$$I_{GP} = \frac{S_i}{S_r} = \frac{100}{\overline{b^2}} \quad (2)$$

where: S_i – geometrical surface corresponding to the non-affected natural state (ideal state of soil component, a circle with the ray of *10*); S_r – geometrical surface corresponding to the real state of environment (real state of soil component, a circle with the ray equal with the value of $\left(\overline{b^2}\right)^{1/2}$), and $\overline{b^2}$ is the evaluation score for soil component (b_{soil}) corresponding to the arithmetic mean of the values attributed to each analyzed soil quality indicator in accordance with the evaluation scale (Fig. 1 and Table 1) [15-20].

For soil component the calculation of geometrical surface is performed using the index value to express the soil quality (EQ_{soil}) that corresponds to a specific evaluation score (ES_{soil}) (compliance degree) (Table 1) [14-15].

The correlation into the alternative methodology of global pollution index is presented into Table 2 [10-11, 17].

Table 1. Correlation scale for the pollution level of soil component (soil quality scale)

Eval. score (ES_i)	Values of EQ_i	Effects on the environmental component and human health
10	0	The environmental component is not affected by the industrial activity. Environment state: natural
9	(0.0-0.2]	The environmental component is affected by the industrial activity. The effect can not be quantified
8	(0.2-0.7]	The environmental component is affected, but under the maximum admissible limits – level 1. Alert level: potential effects
7	(0.7-1.0]	The environmental component is affected, but into maximum admissible limits – level 2. Intervention level: potential effects
6	(1.0-2.0]	The environmental component is affected, over the maximum admissible limits – level 1. The effects are pronounced
5	(2.0-4.0]	The environmental component is affected, over the maximum admissible limits – level 2. The effects are harmful
4	(4.0-8.0]	The environmental component is affected, over the maximum admissible limits – level 3. The harmful effects are pronounced
3	(8.0-12.0]	Degraded environmental component – level 1. The effects are lethal to the average exposure
2	(12.0-20.0]	Degraded environmental component – level 2. The effects are lethal at short times of exposure
1	> 20.0	The environmental component is improper for life

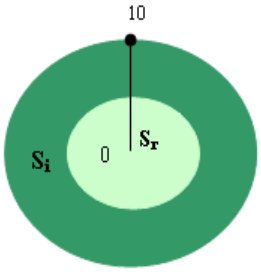


Fig. 1. *Graphical representation of the alternative methodology of I^*_{PG} corresponding to ideal state (S_i) (circle with the ray of 10) and real situation (S_r) (circle with the ray equal with the value of $\left(\overline{b^2}\right)^{1/2}$)[20]*

Table 2. Correlation into the global pollution index methodology

Values of I^*_{PG}	Real situation of environment
$I^*_{PG}=1$	Natural environment, not affected by economic/human activities
$1< I^*_{PG} <2$	Environment modified by economic activities within admissible limits
$2< I^*_{PG} <3$	Environment modified by economic activities generating discomfort effects
$3< I^*_{PG} <4$	Environment modified by economic activities generating distress to life forms
$4< I^*_{PG} <6$	Environment modified by economic activities, dangerous for life forms
$I^*_{PG} \geq 6$	Degraded environment, not proper for life forms

RESULTS AND DISCUSSIONS

The results of the analyzed physico-chemical indicators for *soil* quality from the investigated site are presented in Table 3 (i.e. different soil samples, S_1, S_2, S_3, S_4 collected at depth of 5 - 10 cm onto the investigated site, average value of specific analyzed quality indicators) and Table 4 (i.e. soil samples, S_1, S_2, S_3, S_4 collected at depth of 20 - 40 cm onto the investigated site).

Table 3. The values of quality indicators for soil (depth of 5 - 10 cm)

Quality indicator	Measure unit	$C_{measured}$ value	C.M.A. value [a, b]	EQ_i (soil)	ES_i (soil)
S_1 – soil affected by all activities from a commercial centre					
Active pH	-	7.91	neutral	-	-
Total oil compounds	mg/kg dry soil	400	100 [a]	4	5
TOC	%	18.45	6 [b]	3.075	5
Total N	mg/g soil	1.707	-	-	-
Total P	mg/kg soil	161.082	-	-	-
Gases/ vapours	%	26.285	-	-	-
TSSC	mg/g dry soil	300	< 600	-	-
Calcium	% CaO	13.44	-	-	-
Lead	mg/kg dry soil	9.61	20 [a]	0.481	8
Nickel	mg/kg dry soil	14.12	20 [a]	0.706	7
Cadmium	mg/kg dry soil	0.13	1 [a]	0.13	9
				EQ_{soil} = 1.678	**ES_{soil} = 6.80**
S_2 – soil affected by all activities from a Peco deposit					
Active pH	-	8.97	neutral	-	-
Total oil compounds	mg/kg dry soil	700	100 [a]	7	4
TOC	%	17.91	6 [b]	2.985	5
Total N	mg/g soil	18.108	-	-	-
Total P	mg/kg soil	4.915	-	-	-
Gases/ vapours	%	18.407	-	-	-
TSSC	mg/g dry soil	230	< 600	-	-
Calcium	% CaO	67.20	-	-	-
Lead	mg/kg dry soil	18.58	20 [a]	0.929	7
Nickel	mg/kg dry soil	38.10	20 [a]	1.905	6
Cadmium	mg/kg dry soil	0.14	1 [a]	0.14	9
				EQ_{soil} = 1.192	**ES_{soil} = 6.20**
S_3 – soil affected by railway transport traffic					
Active pH	-	8.98	neutral	-	-
Total oil compounds	mg/kg dry soil	700	100 [a]	7	4
TOC	%	16.29	6 [b]	2.715	5
Total N	mg/g soil	8.990	-	-	-
Total P	mg/kg soil	3.766	-	-	-
Gases/ vapours	%	15.135	-	-	-
TSSC	mg/g dry soil	210	< 600	-	-
Calcium	% CaO	14	-	-	-
Lead	mg/kg dry soil	10.56	20 [a]	0.528	8
Nickel	mg/kg dry soil	31.44	20 [a]	1.572	6
Cadmium	mg/kg dry soil	0.07	1 [a]	0.07	9
				EQ_{soil} = 2.377	**ES_{soil} = 6.40**
S_4 – soil affected by all activities from a ' no functioning' cigarette plant					
Active pH	-	9.10	neutral	-	-
Total oil compounds	mg/kg dry soil	200	100 [a]	2	6
TOC	%	12.84	6 [b]	2.14	5
Total N	mg/g soil	5.521	-	-	-
Total P	mg/kg soil	14.101	-	-	-
Gases/ vapours	%	20.442	-	-	-
TSSC	mg/g dry soil	280	< 600	-	-
Calcium	% CaO	56	-	-	-
Lead	mg/kg dry soil	10.30	20 [a]	0.515	8
Nickel	mg/kg dry soil	12.87	20 [a]	0.644	8
Cadmium	mg/kg dry soil	0.05	1 [a]	0.05	9
				EQ_{soil} = 1.070	**ES_{soil} = 7.20**

[a] M.A.C. according to Ministry Order no. 756/1997, normal levels [14] and regulation from the local environmental conformation plan;
[b] Parrakova TOC value for high polluted soil [13]

Table 4. The values of quality indicators for soil (depth of 20 - 40 cm)

Quality indicator	Measure unit	$C_{measured}$ value	C.M.A. value [a, b]	EQ_i (soil)	ES_i (soil)
S_1 – soil affected by all activities from a commercial centre					
Active pH	-	8.83	neutral	-	-
Total oil compounds	mg/kg dry soil	600	100 [a]	6	4
TOC	%	17.13	6 [b]	2.855	5
Total N	mg/g soil	3.788	-	-	-
Total P	mg/kg soil	55.440	-	-	-
Gases/ vapours	%	19.992	-	-	-
TSSC	mg/g dry soil	320	< 600	-	-
Calcium	% CaO	20.16	-	-	-
Lead	mg/kg dry soil	9.59	20 [a]	0.480	8
Nickel	mg/kg dry soil	14.10	20 [a]	0.705	7
Cadmium	mg/kg dry soil	0.12	1 [a]	0.12	9
				EQ_{soil} = 2.032	**ES_{soil} = 6.60**
S_2 – soil affected by all activities from a Peco deposit					
Active pH	-	9.07	neutral	-	-
Total oil compounds	mg/kg dry soil	700	100 [a]	7	4
TOC	%	14.97	6 [b]	2.495	5
Total N	mg/g soil	2.45	-	-	-
Total P	mg/kg soil	8.130	-	-	-
Gases/ vapours	%	16.348	-	-	-
TSSC	mg/g dry soil	290	< 600	-	-
Calcium	% CaO	57.12	-	-	-
Lead	mg/kg dry soil	18.69	20 [a]	0.935	7
Nickel	mg/kg dry soil	29.78	20 [a]	1.489	6
Cadmium	mg/kg dry soil	0.13	1 [a]	0.13	9
				EQ_{soil} = 2.410	**ES_{soil} = 6.20**
S_3 – soil affected by railway transport traffic					
Active pH	-	9.09	neutral	-	-
Total oil compounds	mg/kg dry soil	800	100 [a]	8	4
TOC	%	15.87	6 [b]	2.645	5
Total N	mg/g soil	1.038	-	-	-
Total P	mg/kg soil	27.88	-	-	-
Gases/ vapours	%	15.135	-	-	-
TSSC	mg/g dry soil	290	< 600	-	-
Calcium	% CaO	19.04	-	-	-
Lead	mg/kg dry soil	10.54	20 [a]	0.527	8
Nickel	mg/kg dry soil	29.88	20 [a]	1.794	6
Cadmium	mg/kg dry soil	0.08	1 [a]	0.08	9
				EQ_{soil} = 2.609	**ES_{soil} = 6.40**
S_4 – soil affected by all activities from a ' no functioning' cigarete plant					
Active pH	-	9.16	neutral	-	-
Total oil compounds	mg/kg dry soil	500	100 [a]	5	4
TOC	%	10.02	6 [b]	1.67	6
Total N	mg/g soil	18.505	-	-	-
Total P	mg/kg soil	25.584	-	-	-
Gases/ vapours	%	20.442	-	-	-
TSSC	mg/g dry soil	220	< 600	-	-
Calcium	% CaO	48.16	-	-	-
Lead	mg/kg dry soil	10.42	20 [a]	0.521	8
Nickel	mg/kg dry soil	12.10	20 [a]	0.605	8
Cadmium	mg/kg dry soil	0.05	1 [a]	0.05	9
				EQ_{soil} = 1.578	**ES_{soil} = 7.00**

[a] M.A.C. according to Ministry Order no. 756/1997, normal levels [14] and regulation from the local environmental conformation plan; [b] Parrakova TOC value for high polluted soil [13]

Due to the calculated index to express the soil quality (EQ_{soil}) into S_1, S_2, S_3 and S_4 site sectors, it can be considered that *soil* is affected, over the maximum admissible limits (level 2 or 3), and the effects are pronounced onto life form and human health.

The evaluation score for soil quality (ES_{soil}) is *6.80* for S_1 sector, *6.20* for S_2 sector, *6.40* for S_3 sector, and respectively *7.20* for S_4 sector (depth of 5 - 10 cm) and respectively, *6.60*, 6*.20, 6.40* and *7.00* at soil depth of 20 - 40 cm into the same site sectors. It can be observed that an important pollutant into these soils that must be periodically monitoring is pH, TOC, total oil compounds and also the heavy metals.

Appling the alternative method of global pollution index, it is calculated the arithmetic mean of evaluation degrees $(\overline{b^2})^{1/2}$. The value of this parameter is ca *6.65* ($\overline{b^2}$ = 44.2225), and I^*_{GP} is *2.261* (depth of 5 - 10 cm), and respectively, *6.55* ($\overline{b^2}$ = 42.903) and I^*_{GP} *=2.331* (depth of 20 - 40 cm), corresponding to the situation of 'environment modified by economic activities generating discomfort effects and risks for health of life forms coexisting onto soil site'.

CONCLUSION

A Romanian urban site is assessed in term of environmental impact using the alternative methodology of global pollution index (I^*_{PG}) in condition of 'restrictive functioning' of all economic activities, economic crisis and deficit.

The evaluation scores for the quality of *soil* in the four main site sectors (S_1- commercial centre sector, S_2– Peco deposit sector, S_3– railway traffic sector and S_4– a non functioning cigarette manufacturing sector) were calculated considering some specific physicochemical indicators of soil quality.

The maximum evaluation score (ES_i) indicating non-polluted soil or natural state into the investigated area is considered to be *10*, and the real evaluation score of soil component was found lower (i.e. values of *6.65*, and *6.55* respectively for depths of 5 - 10 cm, and 20 - 40 cm). The calculated value of global pollution index in condition of mentioned economic activities into the studied site (i.e. $I^*_{PG}=2.261$, corresponding to an 'environment modified by economic activities generating discomfort effects and risks for health of life forms coexisting onto soil site') represents a reference value of global pollution level. This fact requires periodical monitoring actions, pollution control and a developing soil remediation project.

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