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Environmental Impact Assessment for a Unit of Food Aromas and Essences Production Using the Global Pollution Index

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Abstract

One of the most important and actual problems which mankind is confronted with is related to the environment pollution and sustainable development. For an acceptable and legal industrial management is necessary the assessment of environmental impact generated by all industrial activities or companies and, after that, improvements of technologies, raw materials (i.e. use of environment-friendly materials and technologies when is possible), application of the best available techniques (BAT), implementation of European Environmental Management System (EMAS), etc. Thus, following the monitoring, sample collecting and physicochemical analysis of some environment quality indicators into and around the area of studied industrial unit that produces food aromas and essences, it can be evaluated the level of environment pollution and also the impact against different life forms. The environmental impact (EIA) is assessed using the Romanian assessment method of global pollution index (I_{PG}) considering as principal evaluated environment components: air, water and noise. The experimental results correspond to the situation of 'environment modified by industrial/economic activities into admissible limits with no effect on life forms' (I_{GP}= 1.235). In this context, the industrial company was implementing monitoring actions and the most indicated measures in order to prevent environmental pollution, control impact and risk.

Keywords: production of food aromas and essences, environment pollution, environmental impact assessment (EIA), global pollution index (I_{PG})

Introduction

The sustainable management of natural resources and wastes is promoted at European and global scale, aiming to decouple the links between the environmental impacts of natural resource use and waste generation on the one hand, and economic growth on the other. The Directorate-General for Environment (DG Environment) is strongly committed to improving its overall environmental policy-making by focusing on four strategic perspectives: (1) better regulation, an increased accent on implementation, (2) upgraded and better-focused international co-operation, (3) more active integration of environment into other policy areas, as well as by (4) an effort to further improve dissemination of information (i.e. strengthening better regulation principles in environmental policy-making, policy and legislative implementation, international co-operation/global environmental governance, improved policy integration, and information, awareness raising and participation) (DG Environment, 2007). DG Environment will contribute to a high level of quality of life and social well-being for citizens, by providing an environment where levels of pollution are continuously reduced so as to minimize harmful effects on human health and on the environment.

It is recognized the fact that pollution from air, water, soil and noise, as well as various substances present in the environment can significantly affect health and the quality of life. The number and quantity of chemicals that can be found in consumer products and in the wider environment (i.e. air, water, soil/subsoil, forests, terrestrial and aquatic flora and fauna etc.) are continuing to grow, along with increasing scientific concern about their effects on human health. Thus, the monitoring of environment quality into the cities, economic companies or institutes, together with the environmental impact assessment (EIA) generated by all economic activities have become a major objective into the environmental policy and strategy (Zaharia & Murarasu, 2009; Zaharia, 2009).

The support for the use of integrated impact assessments/sustainability impact assessments is growing at different levels and geographic scales of policy-making and planning, both nationally and internationally. However, delivering good quality integrated assessments in the near future could be challenging (Lee, 2005). Increasing emphasis has been placed in recent years on development of the theory of environmental impact assessment (EIA).

There are two main interpretations of the role of science in EIA (EIA as applied science and EIA as civic science) and different distinct models are identified within these paradigms (Cashmore, 2004). There are differences between research and other technical contributions intended to strengthen assessment methodologies and the types of environmental assessment methods considered usable by practitioners (Cashmore, 2004). The development of a common Romanian EIA methodology considered easily usable by practitioners is proposed (Macoveanu, 2005; Zaharia & Surpateanu, 2006; Zaharia et al., 2007).

This Romanian EIA methodology is based on the global pollution index (I_{PG}) proposed by Rojanschi (1991) and can be applied for a minimum three environment components (e.g., water resources such as ground water, surface water, final effluent discharged directly into different emissary, air, soil, noise, health etc.) (Rojanschi, 1991). The case studies of some small or medium productive companies can be assessed by the global pollution index (I_{PG}). Some research studies and environment requirements impose the same quality into the discharging points into the environment (e.g., air or water resources) as the quality into the non-polluted natural environment without consideration of the dilution or self-depollution possibility for any emissions or loads (Zaharia & Murarasu, 2009).

The functional unit of this EIA study is a small Romanian industrial unit (a private company) that produces the commercial products of vanilla sugars, food aromas and essences, natural (E150) and synthesis (E102, E122, E133) dyes, addition and conservation agents for non-alcoholic and alcoholic drinks, sweets, chocolate, cookies, ice creams, etc. The principal raw materials are the natural and synthesis concentrated or/and super concentrated aromas, volatile oils, demineralised water, and some extraction solvents (i.e. specific organic alcohols, ethers, cetones etc.) and also the special glass or plastic wares or recipients for their packaging. The principal technological/economic activities are the manufacturing of these commercial products (i.e. the production technology contains the following technological steps: solubilization/dissolution, homogenization/blending, maturing, packaging, labelling, storage and marketing of all commercial products). This study considers the gaseous emissions from the production sector into atmosphere, the final effluent discharged directly into the urban sewerage, and the noise, as the most important emissions into environment that must be assessed and no emissions on soil/subsoil.

Experimental

Unit characterization and location

The emplacement of this small industrial company is into an important Northern Romanian town (i.e. ca 338 000 inhabitants), and placed near a residential district. The total surface is of 0.24 ha (construction surface of 0.16 ha). All necessary consumption waters are ensured from urban drinkable water supplying system and the final effluent is collected into a final collector basin that discharges into the urban domestic or municipal sewerage. The domestic and production wastes are separately collected and stored into special ecologic containers (i.e. trash cans, dumpsters). These containers are directly transported or discharged periodically into special transportation vehicles, in close system by the special urban sanitation operator and cleaning service.

Sampling and analysis

The environment pollution generated by this private company was established based on the physicochemical analysis concerning: *i*) specific indicators of air quality (e.g., non-methane volatile organic compounds - VOC, SO_x, NO_x, ethyl alcohol, solid particles, having significant impact on air quality); *ii*) specific indicators of water quality (e.g., pH, suspended solids, organic matters expressed as chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5), chlorides, free chlorine, sulphates, extractible substances into organic solvent, total phosphorus, total nitrogen, total residues, having potential impact on sewerage/pipeline system), and *iii)* noise.

All specific environmental indicators have been analyzed by standardized methods (i.e. according to the national and international standards and regulations) (Surpateanu and Zaharia, 2002; Catalogue, 2005; Zaharia, 2008). Some physicochemical indicators for environment quality were determined using directly digital analyzers (i.e. Oldham Plus analyzer for gaseous indicators; Hach One Laboratory digital pH-meter; Sound Level Meter HGL-1004, MeTechnik, Germany) or different quantitative internationally approved analytical methods, spectrophotometrical internationally approved methods or instrumental analytical methods (HPLC, GS-MS) etc. The principal apparatuses used for these analyses were the following: DRELL DR/2000 spectrophotometer (HACH Company), HPLC Aggilent series 1100, Aggilent series 6890N gas chromatograph with FID detector, Agilent 5973 MSD mass spectrometer, Carbo Erba gas chromatograph, and Partner WWPS 510/C/2 digital analytical balance.

Environmental impact assessment

The environmental impact assessment at this private company is assessed by the global pollution index, which takes into account the ideal and real state of environment pollution, considering some quality indicators that are representative for environment into the investigated site. The assessment method consists of synthetic appreciations, based on quality indicators for each environment component (e.g., air, water resource, soil, noise, etc.), and their correlation using a graphical representation (Rojanschi, 1991; Macoveanu, 2005).

The assessment of the environment quality into the industrial unit site is performed for the quality of air, water resource and noise. Thus, there were appreciated some specific quality indicators of each component and after that, correlations were performed based on a graphical representation that permits the calculation of global pollution index as a ratio of ideal surface and real surface. For each environment component it is proposed an evaluation score that quantifies the pollution of the component expressed by an evaluation scale (Rojanschi et al., 1997; Macoveanu, 2005; Robu et al., 2005).

The evaluation scale consists into different variation intervals for the evaluation score that correspond to specific pollution situation. The minimum and maximum value for the evaluation score is 1, and respectively 10, 10 representing the non affected natural state of environment and 1 representing an irreversible and major degradation of the studied environmental components (Macoveanu, 2005; Zaharia & Surpateanu, 2005).

It must be underlined the fact that this method is mainly based on subjective appreciations and the experience of evaluators is very important. The calculation of global pollution index (I_{GP}) is done as in Eq. (1) (Macoveanu, 2005; Rojanschi et al., 1997; Rojanschi, 199; Zaharia & Surpateanu, 2005; Zaharia & Surpateanu, 2006):

$$I_{PG} = \frac{S_i}{S_r} \qquad (1)$$

where: S_i – geometrical surface corresponding to the non-affected natural state (ideal state of environment) and S_r – geometrical surface corresponding to the real state of environment. The geometrical surface can be the surface of a triangle in the case of three environment components (e.g., surface water, air and noise components), a square in the case of four environment components (e.g., air, water, soil and noise components) (Figure 1) (Macoveanu, 2005; Zaharia and Surpateanu, 2005), etc.

Each evaluation score for an environment component (i.e. air, water and noise) corresponds to the arithmetic mean of the values attributed to each analyzed quality indicator in accordance with the evaluation scale.

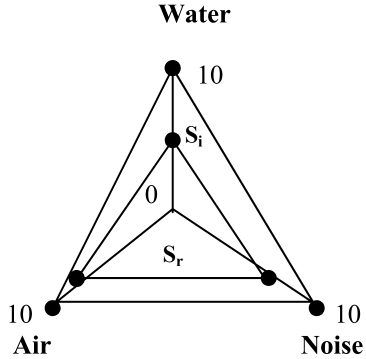

Figure 1. Graphical representation of global environment state: *ideal state* (S_i) and *real state* (S_r)

Literature survey (Rojanschi et al., 1997; Macoveanu, 2005; Robu et al., 2005; Zaharia et al., 2007) proposes for different values of I_{PG} the following characterization of global environmental impact (Table 1).

Table 1. Correlation between the global pollution index and global state of environment

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

Results and discussions

The values of the analyzed physicochemical indicators for the quality of each environment component on the industrial investigated site are presented in Table 2 for air component (i.e. gaseous emissions into atmosphere from the production sector), and in Table 3 for water resource component (i.e. final industrial effluent discharged into sewerage system) (Lupu, 2004).

Table 2. The values of quality indicators into the gaseous emission (air component)

Pollutants	Concentration (mg/Nm^3)	Maximum admissible values*,**
COV	45	150**
NO_2	0	350*
SO_2	0.5	35*
Ethyl alcohol	0.05	-
Solid suspended particles	6	5*

* Maximum Admissible Concentration according to Government Order no. 462/1993.
** Maximum Admissible Concentration according to Government Order no. 499/2003 (for COV concentration in gaseous industrial emissions).

Table 3. Values of the quality indicators for water component: *industrial effluent* (maximum flow of drinkable and industrial water consumption - 125 m^3/month)

Physicochemical indicators	Measured (average annual) values (mg/dm^3)	M.A.C.* – limit from the environmental authorization agreement	M.A.C.**	Quantity (Kg/year)
pH	7.6	6.5-8.5	6.5-8.5	-
Suspended solids	35	60	350	52.50
BOD_5	4.56	25	300	6.84
COD_{Cr}	18.21	100	500	27.32
Chloride	248.20	200	500	372.30
Free chlorine	0.14	0.15	0.20	0.20
Sulphate	138	300	600	207
Extractible compounds	10	20	30	15
Total phosphorus	28	2.0	5.0	4.20
Total nitrogen	4.0	2	10(15)	6.0
Total residues	460	500	500	690

* Maximum Admissible Concentration according to the environmental authorization agreement for industrial unit production (Environment Protection Agency – EPA).
** Maximum Admissible Concentration according to Government Order no. 352/2005 (Technical Norms for Treated Wastewaters discharged directly into urban sewerage, TNTW 002).

Taking into account the evaluation scale (Table 4) (Macoveanu, 2005; Zaharia & Surpateanu, 2005; Zaharia & Surpateanu, 2006; Zaharia & Murarasu, 2009; Zaharia & Surpateanu, 2007) it can be considered that the evaluation scores for each analyzed quality indicator corresponding to a specific pollutant from air component are: VOC - 8; SO_2 - 10; NO_2 – 9, and suspended solids - 9.

The synergetic action of these emitted compounds from the direct discharge in air is expressed by the average arithmetic value of the evaluation scores, and corresponds to an evaluation score for *air component* of *9*. It can be observed that the most important indicator into the gaseous emissions that must be periodically monitored is COV, but a special attention must be given to the content of suspended solids and SO_2.

Table 4. Evaluation scale for air component

Eval. score	Air quality situation	N_xO_y, expressed as NO_2 (mg/m^3)	Solid particles (g/m^3)	VOC (g/m^3)	SO_2 (g/m^3)
10	Air – natural quality	0-0.020	0	0-0.02	0
9	Clean Air – 1st level	0.020-0.150	0.0-0.04	0.02-0.05	0.0-0.02
8	Clean Air – 2nd level	0.150-0.750	0.04-0.06	0.05-0.15	0.02-0.05
7	Affected Air – 1st level	0.750 -7	0.06-0.08	0.15-0.30	0.05-0.2
6	Affected Air – 2nd level	7 -75	0.08-0.1	0.3-0.7	0.2-0.4
5	Polluted Air – 1st level	75 -350	0.1 – 0.16	0.7-1.0	0.4-0.8
4	Polluted Air – 2nd level	350-550	0.16–0.25	1-3	0.8-1.5
3	Degraded Air – 1st level	550-700	0.25 – 0.8	3-5	1.5-4
2	Degraded Air – 2nd level	700-750	0.8 –2.0	5-10	4-8
1	Unbreatheble Air	>750	> 2.0	>10	> 8

The evaluation score for final effluent discharged into the urban sewerage system (included into the potential category of water resources as the fifth one) (Zaharia, 2008) was determined considering the following quality indicators: suspended solids, COD_{Cr}, BOD, chlorides, free chlorine, extractible compounds, sulphate, total phosphorus, total nitrogen and total residues.

Considering the evaluation scale for the *water component* (Table 5), the evaluation scores for each quality indicator from the final industrial wastewater effluent are: suspended solids - 9, COD_{Cr} - 7, BOD - 8, chlorides - 8, free chlorine - 7, extractible compounds - 7, sulphate - 8, total phosphorus - 9, total nitrogen - 9 and total residues - 8.

Table 5. Evaluation scale for *water resource component*

Eval. scale	Water category	COD-Cr (mg/L)	BOD_5 (mg/L)	Chlorides (g/L)	N total (mg/L)	Susp. solids (g/L)	Total residues (g/L)	Extractib. comp. (mg/L)	Sulphates (mg/L)	Total P (mg/L)	*Free chlorine (mg/L)*
10	Drinkable water	< 5	< 3	0-0.02	< 4	< 0.01	fond	< 1	< 80	< 1	*0*
9	Category I	5	3	0.02-0.1	4	0.01-0.035	< 0.2	1-3	80	1-3	*0-0.05*
8	Category II	5-10	3-5	0.1-0.25	4-13	0.035-0.07	0.2-0.5	3-5	80-150	3-5	*0.05-0.1*
7	Category III	10-20	5-10	0.25-0.4	13-26	0.07-0.15	0.5-1	5-10	150-250	5-10	*0.1-0.15*
6	Category IV	20-50	10-25	0.4-0.6	26-66	0.15-0.35	1-1.3	10-15	250-300	10-15	*0.15-0.45*
5	Category V	50-100	25-30	0.6-0.7	66-75	0.35-0.50	1.3-1.5	15-20	300-500	15-20	*0.45-0.75*
4	Degradation 1st phase	100-150	30-50	0.7-0.9	75-85	0.5-0.7	1.5-1.7	20-25	500-700	20-25	*0.75-1.25*
3	Degradation 2nd phase	150-300	50-100	0.9-1	85-95	0.7-0.85	1.7-1.8	25-30	700-800	25-30	*1.25-2.25*
2	Wastewater 1st level	300-400	100-500	1-1.2	95-100	0.85-1	1.8-2	30-35	800-900	30-35	*2.25-3.5*
1	*Wastewater 2nd level*	*> 400*	*> 500*	*> 1.2*	*> 100*	*> 1*	*> 2*	*> 35*	*> 900*	*> 35*	*> 3.5*

The average evaluation score for *water component* in the case of final industrial effluent discharged into sewerage system is of *8*. The most important quality indicators are organic matters expressed by COD and BOD, extractible compounds, free chlorine, sulphate and also total phosphorus, nitrogen and residues.

Outside of production sector building (i.e. the N, E, S, V side), there were performed directly measurements of noise using the Sound Level Meter HGL-1004. The values of noise were of 56.20, 54.40, 56.20, and 53.20 dB, respectively. The average value for noise in this environmental impact evaluation is of 55 dB. According to the Romanian standard no. 10009/88, the maximum admissible limit for Leq is of 65 dB (A) at the building limit, and the maximum acceptable value for human body is of 45 dB. In this context, the average evaluation score for *noise* is of *9*.

According to the proposed evaluation scale (Tables 4 and 5) for air, water resources and noise (the noise scale accepted by the environmental authority as the Local Environmental Agency), the quality of environment can be appreciated through the following evaluation scores: *air component* - 9, *water component* - *8* and *noise* - 9. Appling the impact assessment methodology of global pollution index, the ideal and real surface are calculated (i.e. S_i= 29.713 and S_r= 24.067) corresponding to each triangle of Figure 1.

The global pollution index (I_{PG}) has a value of *1.235*, and corresponds to the situation of '*an environment modified by industrial/economic activities into admissible limits with no effect on life forms*'.

Conclusions

A small private company producing food aromas and essences was assessed in term of environmental impact using the method of global pollution index (I_{PG}). The evaluation scores for the *air component* (gaseous emissions), *water component* (final effluent) and *noise* were calculated considering some specific quality indicators having the values of *9, 8,* and *9* respectively. The maximum evaluation score indicating non-polluted environment or natural state is considered to be *10*, and the real evaluation score for each environment component into the investigated industrial site is between *8 - 9*.

The I_{PG} value is of *1.235* and corresponds to the situation of 'an environment modified by industrial/economic activities into admissible limits with no effect on life forms'. This fact requires continuous pollution control for minimization of all emissions into environment.

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