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# Control Study of Siret River Quality in Pascani County Area and Estimation of Its Pollution Level

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**Abstract:** The study presents some authors' experimental results for determination of some quality indicators (few general, specific and toxic physical-chemical indicators) analyzed at the beginning of summer season (June, 2013), in three control sections of Siret River in Pascani town area (*i.e.* Lunca-Pascani entrance, 1 km-upstream, and 1 km-downstream of Pascani bridge, respectively*)*. The real pollution status of Siret River in Pascani town area is also estimated by the global pollution index ($I^*_{GP}$), and corresponds to values between 3.215-3.891 indicating '*an aquatic environment modified by domestic and economic activities alongside the river with generation of stress effect against life forms*'.

***Keywords*:** Water quality indicators; Quality index ($EQ_w$); Evaluation score ($ES_w$); Global pollution index ($I^*_{GP}$); Real water pollution status; Siret River; Pascani town area.

## Introduction

All over the world, the importance of fresh water is evident in condition of only 0.02% of Earth's total water supply in easily accessible

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surface forms (rivers, ponds and lakes) essentially required for the survival and growth of many forms of animal and plant life on the planet.[1,2] Many of the fresh water properties are unusual, even unique. Therefore, the people concern is obvious for both fresh water quantity, and also its quality.

In terms of quantity, the fresh water is constantly diminishing each year, in condition of an inequity of world water distribution, from over 600,000 $m^3$/day/inhabitant in Iceland, to 10,000 in Sweden and Malaysia, to 3,000 in France and India, to 250 in Israel and Saudi Arabia, or no more than 100 in different poor or developing states.[1,3]

In terms of quality, the fresh water is also highly variable because of many chemical, biological and microbiological compounds, influencing its acceptibility for different purposes. The appreciation of fresh water quality is due by some water quality indicators (*i.e.* physical, chemical, biological, microbiological, or toxicological indicators).[2,3,4]

Of all the environmental issues involving water, contamination by particulate matter, different dissolved toxic metal species or petroleum products is one of the most visible. This problem is often reffered to as 'particulate pollution' or 'heavy metal pollution' or 'petroleum oil pollution'. The fresh water quality protection is very important in terms of conservation as a vital natural resource, and also prevention of water pollution starting from the source, at catchments or watershed scale.[3]

The quality of watercourses passing through different administrative locations or zones (*i.e.* different towns and villages, etc.) is generally affected in comparison with the natural origin status. Therefore, the 'polluter pays' principle may be applied by the environmental regulators considering the real pollution status, significance or gravity of impact produced by polluter.

The water resource management involves permanent monitoring actions of water quality (*i.e.*, supervision, operational, or investigation monitoring depending of the contamination status of water bodies) in different important hydrological basins of some important Romanian watercourses (*e.g.*, in Moldova zone: Prut, Siret, Bistrita, etc.)[3,5,6,7], together with evaluation of environmental impact produced by the local city/town social and economical development against the aquatic environment nearby.

The diagnosis of environmental impact due to different social and economical activities (*e.g.,* productive, commercial, transport, agricultural, domestic activities, storage facilities, etc.) in an administrative zone still remains one of the first stage for the complete evaluation of sustainability of a strategic development plan or programme achieved at individual or mixed levels by one or more social and/or economic units/plants/industrial site. This is the reason for why the aquatic environmental impact assessment caused by the whole social-economical development in the studied Romanian town area is estimated by the global pollution index ($I^*_{GP}$), and also the water quality expressed by a quality index ($EQ_w$).[8,9,15,16] This is one of the paper target which evaluates the whole productive and domestic activities in June month (2013) in order to follow the development strategy adopted by the local administrative and environmental authorities considering the environmental protection requirement in context of the regional economical and social development strategy.

Therefore, the paper focuses on presentation of some authors' laboratory analysis, and interpretation of Siret River quality in Pascani town area (*i.e.* three control sections in Pascani town area: Lunca-Pascani entrance, 1 km-upstream, and 1 km-downstream of Pascani bridge, respectively). Some general physical and chemical quality indicators (*i.e.*

colour, pH, temperature, turbidity, conductivity, suspended solids, total hardness, oxygen regime indicators as dissolved oxygen, chemical oxigen demand (COD), and some selective salt content as chlorides, sulphates, nitrates, ammonia, phosphates, total P), and two specific dangerous chemical quality indicators as phenolic derivates, extractible substances in organic solvents at the beginning of summer season (June, 2013) were analysed, and evaluated in order to express the real aquatic environment pollution status by the global pollution index ($I^*_{GP}$) using the alternative methodology, considered as an initial/preliminary evaluation of cumulative effects and local impact.[8,9]

## Experimental

### *Characterization of Siret River and the three control sections*

Siret River (15,157 Km length, on Romanian territory) springs from Carpatian mountains of Northern Bucovina (altitude of 1,238 m from the sea level), in Ukraine (679 Km length), and is considered as the most important inffluent of Danube River (nearly Galati town), having an average multiannual flow of ca 250 $m^3/s$. In addition, it is representing the biggest hydrological basin from Romanian territory, passing nearly Siret, Pascani and Roman towns.

The surface water resources of Siret hydrological basin (Siret h.b.) represent ca 17 % from the total volume of water resources of our country (*i.e.* 28,116 $Km^2$, with a length of hydrogeographical network of 10,280 Km, an average density of 0.37 $Km/Km^2$), and are constituted, in principal, of Siret River and its inffluents (*i.e. right side*: Siretul Mic, Suceava, Moldova, Bistrita, Trotus, Putna, Buzau, and *left side*: Polocin and Barlad) but also of some natural and accumulation lakes. The total estimated volume

of natural water resources of Siret h.b. is of 6,868 millions $m^3$ from which: 5,800 millions $m^3$ - surface water resources, and 1,068 millions $m^3$ - ground water resources, deserving more than 2,500,867 inhabitants, from which: 39.6% (990,379 inhabitants) in urban area.[10]

In the Siret h.b. exists over 31 important water artificial accumulations for different uses having an useful volume of 1847.63 millions $m^3$, and also two natural lakes, its water still not utilised.[11]

The water quality of Siret River is periodically monitoring by A.P.M. Iaşi (Environmental Protection Agency, Iasi) and A.N. Apele Române Company – Direcţia Apelor Siret (Siret Waters Sector), by analysing some groups of quality indicators daily, weekly, or monthly (oxygen regime, mineralization level; *e.g.*, COD-Mn/CCO-Cr, $BOD_5$, ammonia-$NH_4^+$, etc.).

The location of control sections from where were periodically sampling the water in special PP plastic recipients of 1000, or 2500 $cm^3$ (complete filling, no air bubbles inside) was alongside the Siret River in the area of Pascani town, Romania (*i.e.* ca 26.100 inhabitants)[10], from three water control sections: $P_1$- upstream of Pascani-Lespezi entrance; $P_2$- 1 km-upstream of Pascani bridge; $P_3$- 1 km-downstream of Pascani bridge. The samples were immediately transported in safe-constantly thermal conditions (some of its in refrigerating system/box, 5-10°C) to the analysis laboratory in no more than 1.5-2 hours. Some analyses were performed at the sampling control sections (temperature, pH, color, smell, etc), and the others at laboratory sett-up scale on preserved (with specific chemical reagents; *e.g.*, HCl conc for determination of extractible substances, or NaOH 5N for sulphides and its derivates, etc.), or refrigerated samples (after attaining the room temperature). For appreciation of water quality in the first period of June month (2013), there were mediated the results of ten samples collected

from each control section (daily period with intense traffic and economic activities), the average values being considered further for water quality and impact assessment.

The water quality monitoring upstream and downstream of Pascani town permits an evaluation of environmental impact produced by different types of activities performed in this municipality area.

### *Materials and methods*

The laboratory analyses of some physical-chemical indicators were performed according with Romanian standard methods internationally approved (SR ISO and/or SR EN), as well as the reference materials, chemical reagents, and operating parameters for gravimetric, volumetric, or spectrophotometrical methodology used:[3,12,13]

- *General physical-chemical indicators*: pH (SR ISO 10523-97); temperature (thermometer); color (firstly visual, SR ISO 7887/1997); turbidity (SR EN ISO 7027: 2001), suspended solids (STAS 6953-81); conductivity (conductivity Meter - Radelkis OK 102/1); suspended solids (test #630 spectrophotometer Drell DR 2000, HACH); turbidity (test #750 spectrophotometer Drell DR 2000, HACH); total hardness (with EDTA); oxygen regime as dissolved oxygen (SR EN 25814/1999), chemical oxygen demand (COD-Mn) (SR ISO 6060/1996, or SR EN 1484/2001), salinity indicators as fixed residues (STAS 6963-81);

- *Specific chemical indicators* for the content of some anions and cations as nitrates (STAS 7890/1,2-98), phosphates (SR EN 1189/2000), sulfates (STAS 8601-70), chlorides (STAS 3049-88 or SR ISO 9297/98), ammonia (STAS 6328-85 or SR ISO 7150-1/2001), total nitrogen (SR EN ISO 13395:2002), total phosphorus (STAS 10064-75);

- *Specific toxic indicators* as phenol and phenol derivates (SR ISO 66439:2001 or SR ISO 8165-1/2000) and extractible substances in organic solvents (SR 7587-96).

All chemical reagents used have high analytical purity degree (p.a.). The pH adjustment was done using 0.1 M HCl, and 0.1 M NaOH solutions. The analytical control of water sample quality was performed with help of different individual and multifunctional apparatuses (Hach One-Laboratory pH-meter; DRELL DR/2000 spectrophotometer, Hach Company; Plus SP-830 MeterTech spectrophotometer), conventional methods for COD-Mn/$I_{Mn}$, sulfates, total hardness, extractible substances, fixed residues, as well as spectrophotometrical methods for nitrates, phosphates, and phenol derivates.[2,3,4,10,14]

The collected samples were kept in specific conservation and storage conditions (refrigeration) more than 7 days for data validation. The analysis method sensibility depends of type, standard/reference materials, used apparatuses, the accuracy, or precision being good enough for evaluation of water quality (0.01-0.0001 M).[3,4]

***Environmental impact assessment methodology***

The values of analyzed quality indicators of Siret River are used in calculation of water quality indexes, $EQ_i$ (Eq.1), and also of evaluation scores, $ES_i$, expressed by marks between *1* and *10* attributed based on evaluation scale presented in other authors' researches.[8,9,15,16]

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

in which, $i$ – identification of the specific quality indicator; $C_{i,measured}$ – measured/analyzed value of the quality indicator, and $MAC_i$ – maximum admissible concentration of the quality indicator in accordance with the imposed limits of local environmental authority/regulator or legislation.

The cumulative effect of different potential polluting components is expressed by the average arithmetic value (*i.e.* $EQ_{water}$ *or* $ES_{water}$) of all quality indicators ($EQ_i$) or evaluation scores ($ES_i$). For quantification of the environmental impact is calculated the global pollution index ($I^*_{GP}$) (Eq.2), using the alternative methodology proposed by Popa et al.[8,9,15,16]

$$I^*_{GP} = \frac{S_i}{S_r} = \frac{100 \cdot n}{ES_1 \cdot ES_n + \sum_{i=1}^{n-1} ES_i \cdot ES_{i+1}} = \frac{100}{\overline{ES^2_w}} \qquad (2)$$

where: $S_i$ – geometrical surface of non-affected natural state (ideal state of environment, a circle with ray of *10*), $S_r$ – geometrical surface of real environment state (real state, a circle with ray of $ES_w$), $n$ - number of investigated quality indicators, $ES_i$ - the evaluation score corresponding to $i$ quality indicator, $\overline{ES^2_w}$- average value of all values for $(ES_i)\cdot(ES_{i+1})$ (i=1,2,...,n-1) that can finally express the global aquatic environment evaluation score ($ES_w$) (Fig.1).[17,18,19,20]

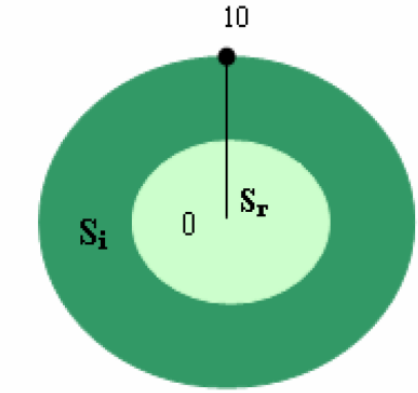


**Figure 1.** Graphical representation of the alternative methodology of global pollution index ($I^*_{GP}$) ($S_i$ - ideal state and $S_r$ - real state).[8,9,17,18]

The correlation between the global pollution index ($I^*_{GP}$), real state of aquatic environment of Siret River, and the impact of different activities in Pascani town area is characterized in table 1.[8,9,15-20]

**Table 1.** Correlation ($I^*_{GP}$) – local pollution status of aquatic environment in the alternative methodology of global pollution index.[8,9]

| $I^*_{GP}$ values | Real pollution status of natural aquatic environment |
|---|---|
| $I^*_{GP}=1$ | Natural aquatic environment, unaffected by all activities in town area |
| $1 < I^*_{GP} < 2$ | Aquatic environment modified by all activities from town area in admissible limits |
| $2 \leq I^*_{GP} \leq 3$ | Aquatic environment modified by all activities in town area, with generation of discomfort effects |
| $3 \leq I^*_{GP} < 4$ | Aquatic environment modified by all activities in town area, with stress generation against organisms |
| $4 \leq I^*_{GP} < 6$ | Aquatic environment modified by all activities, dangerous for organisms |
| $I^*_{GP} \geq 6$ | Polluted aquatic environment (degraded), improper for organisms |

## Results and discussion

The principal pollution sources of surface water in the Siret River hydrographic basin are consisting in point or diffuse pollution sources such as: *1*- human agglomerations (which have wastewater collection systems with or without treatment plants, discharging directly in natural aquatic receptor; also, agglomerations < 2,000 e.i.); *2*- industry (different industrial companies/services); *3*- agriculture as: farms which discharged some dangerous substances and/or priority substances over admissible legislative limits, other agricultural units with point discharging, etc. Some sensible, or vulnerable zones at the nitrates pollution from agricultural sources were found in 54 territories of villages from different regions as: Suceava (18 villages), Iaşi (11 villages), Neamţ (15 villages), Bacău (10 villages).[10]

The most important industrial companies which discharged wastewaters in Siret River in the area of Pascani town are consisting of: (*i*) S.C. Apa-Canal S.A. Pascani (a wastewater treatment plant, with an overall reported treatment degree of 60-85% for the majority of quality indicators, still insufficiently – requirements of more than 75-85%; the affected quality

indicators are especially $BOD_5$, COD-Cr, ammonia); (*ii*) S.C. Kosarom S.A. Paşcani (a meat processing company, with an average daily water consumption of 500 L water per each slaughtered animal), and (*iii*) *S.C. ROMPAK S.A. Pascani (a panification yeast production company, final effluent discharged directly in aquatic natural receptor loaded with organic substances, majority dissolved as dextrines, sugars, resins, organic acids, and rest of yeasts).*

The Siret River quality in Pascani County area is monitorized by both companies: *A.P.M.* Iaşi and *A.N. Apele Române – Direcţia Apelor Siret*, by analyzing of different groups of quality indicators (oxygen regime, mineralization level, etc.), and also of 6 control drilling wells downstream of Pascani towns by the independent *Hydrotechnical System Paşcani* (subdivision of *A.N. Apele Romane - Directia Apelor Siret*) (two on the Siret River left bank, and four on right bank).

The results of physical-chemical analyses performed for water samples collected from the three control sections, in June month (2013) are presented in table 2, and compared with the reference maximum limits for $I^{st}$ and $II^{nd}$ surface water categories, and also quality norms for potable (drinkable) water. Further more, ten analysed quality indicators were used for calculation of the quality indexes ($EQ_i$), and evaluation scores ($ES_i$), considering their maximum admissible concentrations related to $II^{nd}$ surface water category, the results being synthesized in table 3.

From table 2, is notable the fact that at the entrance in Pascani town area (P1- Lespezi-Pascani) the Siret River quality is already affected by the watercourse flowing through different previous administrative zones (Siret town - Suceava County area, different rural areas) which receives also its inffluents (possible polluted from qualitative point of view), and also

directly discharges in it (different final polluting discharges from economic companies or residential sites). The passing through Pascani town area was loaded the water of Siret River with a supplementary content of chemical species (especially nitrogen, phosphorus compounds, organic species, suspended solids, etc.).

**Table 2.** Values of analysed quality indicators of Siret River (June 2013).

| Quality Indicator | P1 | P2 | P3 | M.A.C I$^{st}$ categ. | M.A.C. II$^{nd}$categ. | M.A.C. Drink.w. |
|---|---|---|---|---|---|---|
| pH | 7.57-7.58 | 7.05 | 7.44 | 6.5-8.5 | 6.5-8.5 | 6.5-9.5 |
| Temperature, $^{o}$C | 23 | 24 | 24 | - | - | - |
| Color, HU - Hazen unit / | 322.3 | 382.14 | 316.964 | 50 | 200 | 20 |
| Absorbance A436 | 0.378 | 0.429 | 0.378 | | | |
| A456 | 0.361 | 0.428 | 0.355 | | | |
| A525 | 0.284 | 0.357 | 0.309 | | | |
| A620 | 0.235 | 0.289 | 0.268 | | | |
| Conductivity, uS/cm | 300 | 300 | 310 | - | - | 2500 |
| Suspended solids, mg/L | 96 | 132 | 124 | 20 | 60 | - |
| Turbidity, FTU | 88 | 112 | 103 | - | - | < 5 |
| Dissolved oxygen,mg $O_2$/L | 8.416 | 6.379 | 5.86 | 7 | 6 | > 6 |
| COD-Mn, mg $O_2$/L | 7.6 | 8.4 | 8.64 | 5 | 10 | < 5 |
| Sulfates, mg $SO_4^{2-}$/L | 584.33 | 732.47 | 683.09 | 80 | 150 | 250 |
| Chlorides, mg/L | 21.30 | 28.40 | 24.85 | 70 | 100 | 250 |
| Nitrates, mg N-$NO_3$/L | 9.823 | 14.432 | 10.199 | 1 | 3 | 11.66 |
| Ammonia, mg $NH_4^+$/L | 1.806 | 1.824 | 1.081 | 0.2 | 0.3 | 0.5 |
| Phosphates, mg $PO_4^{3-}$/L | 2.684 | 2.476 | 2.746 | 1 | 2 | 0.1 |
| Total P, mg P/L | 8.751 | 8.073 | 9.030 | 1 | 2 | 0.1 |
| Extractible substances, mg/L | 13.17 | 26.26 | 26.28 | 20 | 25 | 20 |
| Phenol and its derivates/ Phenol index, mg/L | 8.07 | 7.529 | 7.237 | 0.005 | 0.001 | 0.001 |

According with data from table 3, the following correlations between the quality indexes ($EQ_i$), evaluation scores ($SE_i$), and pollution level of aquatic environment for Siret River, in the three control sections of Pascani town area, must be mentioned:

- concerning the content of *chlorides* and *extractible substances*, the water of Siret River is affected but in maximum admissible limits - I level (alert level: potential effects);

- concerning the content of *organic substances* expressed by *COD-Mn / $I_{Mn}$*, the water of Siret River (Pascani municipal zone) is affected but in admissible limits - II level (intervention level: potential effects).

The water of Siret River in Pascani town area is considered as affected over the maximum admissible limits in the following ranges:

- I level (the effects are pronounced) related to *suspended solids* and *phosphates content*;
- II level (the effects are dangerous/harmful) related to *nitrates* and *sulphates content*;
- III level (the dangerous/harmful effects are pronounced) related to *ammonia* and *total phosphorus content*, and degraded-level I related to phenol and its derivates.

The performed data indicate evidently the necessity of continuous monitoring of water quality for Siret River in Pascani town area for identification of each supplementary local pollution episodes, non-reported by polluters to the competent authority of environmental protection (A.P.M. Iasi) as a result of both accidental non-controlled (or wanted) discharges of insufficiently treated wastewaters, and directly discharges of wastes and liquid residues in Siret River.

Data from table 3 indicate that the quality indexes ($EQ_i$) in the three control sections of Siret River have average values between 2.886-3.295, and average evaluation scores ($ES_i$) of 5.20-5.60, appreciating the real pollution state in comparison with the non-polluted status (ideal state) corresponding to an evaluation score of 10.

**Table 3.** Values of $EQ_i$ and $ES_i$ in the three control sections of Siret River from Pascani municipal area.

| Quality Indicator | P1 - Entrance Lunca Pascani | | P2 – 1 km- Upstream of Pascani bridge | | P3 – 1 km- Downstream of Pascani bridge | |
|---|---|---|---|---|---|---|
| | $EQ_{1,i}$ | $ES_{1,i}$ | $EQ_{2,i}$ | $ES_{2,i}$ | $EQ_{3,i}$ | $ES_{3,i}$ |
| Suspended solids, mg/L | 1.6 | 6 | 2.2 | 5 | 2.067 | 5 |
| COD-Mn, mg $O_2$/L | 0.76 | 7 | 0.84 | 7 | 0.864 | 7 |
| Nitrates, mg N-$NO_3$/L | 3.274 | 5 | 4.811 | 4 | 3.3996 | 5 |
| Ammonia, mg $NH_4^+$/L | 6.02 | 4 | 6.08 | 4 | 3.603 | 5 |
| Phosphates, mg $PO_4^{3-}$/L | 1.342 | 6 | 1.238 | 6 | 1.373 | 6 |
| Total P, mg P/L | 4.376 | 4 | 4.037 | 4 | 4.515 | 4 |
| Sulphates, mg $SO_4^{2-}$/L | 3.896 | 5 | 4.883 | 4 | 4.554 | 4 |
| Chlorides, mg/L | 0.213 | 8 | 0.284 | 8 | 0.2485 | 8 |
| Extractible substances, mg/L | 0.527 | 8 | 1.050 | 6 | 0.8 | 7 |
| Phenol and its derivates / Phenol Index, mg/L | 8.07 | 3 | 7.529 | 4 | 7.237 | 4 |
| Average | 3.0078 | 5.60 | 3.2952 | 5.20 | 2.8661 | 5.50 |

The results permit the calculation of global pollution index ($I^*_{GP}$) using the alternative methodology and appreciation of impact effects due to cummulative actions of ten investigated/analysed quality indicators.

The value of global pollution index ($I^*_{GP}$) from table 4 varies between 3.215-3.322 at entrance and finishing of Pascani town area, and corresponds to a real status of Siret River of '*aquatic environment modified by economic and domestic activities with generation of stress against life forms*".

As result of quality impact evaluation, it is recommended the implementation of preventive protection programme for each economic activity (industrial, commercial, agricultural activities, transport, storaging activity, etc.) but firstly the continuous and rigurous control or evaluation of local pollution alongside the Pascani town area (especially upstream and downstream of directly dischaging points in Siret River or bridge site which permits ease reception from population or passagers from terrestrial traffic

of different kinds of wastes, or untreated final effluents from discharging local companies; *e.g.*, Rompak, Kosarom, Apa-Canal Pascani, etc.).

**Table 4.** Values of $ES_w$ and $I^*_{GP}$ in the three control sections of Siret River from Pascani town area.

| Control Section | $\overline{ES_w^{\,2}}$ | $ES_w$ | $I^*_{GP}$ | Real pollution status of aquatic environment |
|---|---|---|---|---|
| P1 – Entrance Lunca-Pascani | 31.10 | 5.576 | 3.215 | *Aquatic environment modified by economic and domestic activities with generation of stress effects against the life forms* |
| P2 - 1 km-upstream of Pascani bridge | 25.70 | 5. 070 | 3.891 | |
| P3 – 1 km-downstream of Pascani bridge | 30.10 | 5.486 | 3.322 | |

It seems that the discharges in Siret River before 1 km-upsteam of Pascani River are highly loaded with polluting substances, or the discharging flow was higher (higher flow received in Siret watercourse) than the usual one (hourly, or daily one). The dillution phenomenon of polluting discharging loads are active, and that is why 1-km downstream of Pascani bridge the global pollution index ($I^*_{GP}$=3.222) has a lower value than that at 1-km upstream of Pascani bridge ($I^*_{GP}$=3.891).

*Environmental risk assessment*

The quantification of environmental risk is based on a simple classification system, in which the probability and gravity of an polluting event (or economic activity discharging its final effluent in watercourse nearby, thus receiving additional potential polluting substances) are considered as decreasing, being attributed an aleatory score as in table 5.

This model serves for qualitative evaluation of environmental risk, and also quantitative risk evaluation. Therefore, the risk is calculated by multiplying these two factors (probability, and gravity), for obtaining a

comparative mark for different risk evaluation cases. Much higher the result is, much higher the priority to control the environmental risk.

**Table 5.** Quantification of environmental risk - *Simplified model*.

| Classification of probability (P) | | | Classification of gravity (G) | | |
|---|---|---|---|---|---|
| 3 = high | 2 = medium | 1 = low | 3 = major | 2 = medium | 1 = ease |
| Risk (R) = Probability (P) x Gravity (G) | | | | | |
| 1 - 3 = | Minor risk | 3 - 6 = | Medium risk | 6 - 9 = | Major risk |

The matrix for analysis of source - pathway - receptor in the case of environmental risk evaluation due to presence of toxic substances in Siret River, Pascani town area is presented in table 6 for two toxic substances.

**Table 6.** Matrix analysis for environmental risk evaluation.

| Toxic substance | Danger | Sourse | Pathway | Targets (water, human, aquatic fauna and flora) | Affecting source | Affecting source | Remediation necessity |
|---|---|---|---|---|---|---|---|
| Phenol and its derivates | toxic | urban and industrial wastewater | Discharge/ evacuation | all | yes | major | yes |
| Extractible substances | toxic | urban wastewater | Discharge/ evacuation | all | yes | medium | yes |

*Quantitative and qualitative risk analysis*

Quantification of environmental risk for the toxic substances (*i.e.* phenol and its derivates, and extractible sunstances) is presented in table 7.

**Table 7.** Quantification of environmental risk.

| **Toxic substances** | **Probability** | **Gravity** | **Risk value** | **Qualitative evaluation** |
|---|---|---|---|---|
| Phenol and its derivates | 3 | 2 | 6 | Major risk |
| Extractible substances | 2 | 2 | 4 | Medium risk |

Analysing the experimental data for the two toxic substances investigated for estimation of environmental impact and risk, in the case of Siret River - Pascani town area, may be concluded that the phenol polluting risk is *major*, and the polluting risks of extractible substances is *medium*. Remediation measures must be had in view, and also risk control.

## Conclusions

Some general, specific and toxic physical-chemical quality indicators were analyzed for appreciation of pollution status of Siret River in Pascani town area (*i.e.* three control sections, P1-P3 at Pascani town area entrance and upstream/downstream of finishing bridge), and it was found that some quality indicators had values that exceeded the maximum admissible limits. Also, few of investigated quality indicators (10 indicators) were used for calculation of global pollution index ($I^*_{GP}$) by application of alternative methodology, and the calculated values were varied between 3.215-3.891, corresponding to a real status of Siret River pollution as '*aquatic environment modified by economic and domestic activities with generation of stress effects against life forms'*.

The environmental risk estimation was also performed, and the phenol polluting risk was found major, and medium for extractible substances respectively.

These data indicate the necessity of continuous monitoring of Siret River quality in the three investigated control sections for identification of different pollution episodes, non-reported by polluters to the local environmental regulators.

## References

1. VanLoon, G.W.; Duffy, S.J. *Environmental chemistry – a global perspective.* Oxford University Press, 2nd ed. **2010**, New York, pp 197-212.
2. Zaharia, C. *Elements of aquatic environment chemistry* (in Romanian). Performantica Ed., Iaşi **2011**, pp 45-80.

3. Zaharia, C.; Teslaru, M.I. Control and analysis of some water quality indicators of Bahlui River in Iasi county area (spring season). *Bul.Inst.Polit. Iasi*, series: Chemistry and Chemical Engineering **2012**, *LVIII(LXII)* (2), 69-79.
4. Danalache, E.; Zaharia, C. Control of some quality indicators of Prut River in two control sections (Radauti and Darabani) (spring season). *Scientific papers* (in Romanian: Lucrari stiintifice), series: Horticulture **2013**, *56* (2), 531-536.
5. Teodosiu, C.; Cojocariu, C.; Musteret, C.P.; Dascalescu, I.G.; Caraene, I. Assessment of Human and Natural Impacts Over Water Quality in the Prut River Basin, Romania. *Environ. Eng. Manag. J.* **2010**, *8* (3), 1439-1450.
6. Lozba-Stibuleac, R.S.; Giurma-Handley, C.R.; Giurma, I. Water Quality Characterization of the Prut River. *Environ. Eng. Manag. J.* **2011**, *10* (3), 411-419.
7. Benchea, E.R.; Cretescu, I.; Macoveanu, M. Monitoring of Water Quality Indicators for Improving Water Resources Management of Bahlui River. *Environ. Eng. Manag. J.* **2011**, *10* (3), 327-332.
8. Zaharia, C. A comparative overview of the environmental impact assessment produced by different economic activities using the global pollution index. *Proceeding of the 15th International Conference – Modern Technologies, Quality and Innovation*, May 25-27, Vol.II **2011**, 1185-1188.
9. Zaharia, C. Evaluation of environmental impact produced by different economic activities with the global pollution index. *Environ. Sci. Pollut. Res.* **2012**, *19* (6), 2448-2455.
10. Radu, I.E. Evaluation of Siret River pollution level and also of environmental risk (Pascani municipality) (in Romanian). *Dissertation Project:* 'Gh.Asachi' Technical University of Iaşi, sci. coord.: assoc. prof. C. Zaharia, pp 4-38.
11. *http://www.apesiret.usv.ro*
12. Surpateanu, M.; Zaharia, C. *Environmental chemistry. Manual of practice applications*. Rotaprint ,Gh.Asachi' Technical University Publishing House **1999**, Iasi, pp 63-92.
13. Surpateanu, M.; Zaharia, C. *ABC – Analysis Methods for Control of Environmental Factors*. T Press **2002**, Iasi, pp 63-140.
14. Zaharia, C.; Suteu, D. Comparative overview of chemical processes in water of Bahlui River. (I) Coagulation-flocculation processes. *CISA: Proc. 7th Int. Conf. Applied Sciences, Chem.and Chem.Eng.*, Bacau, Romania, May 15-18 **2013**, 89-107.
15. Popa, C.; Cojocaru, C.; Macoveanu, M. Geometrical correlation method for global estimation of the ecosystem state. *Environ. Eng. Manag. J.* **2005**, *4* (4), 437–447.
16. Macoveanu, M. *Methods and techniques of ecological impact assessment* (in Romanian). Ecozone Publishing House, 2nd edn. **2005**, Iasi, pp 54-88.
17. Zaharia, C.; Murăraşu, I. Environmental impact assessment induced by an industrial unit of basic chemical organic compounds synthesis using the alternative method of global pollution index. *Environ. Eng. Manag. J.* **2009**, *8* (1), 107-112.

18. Zaharia, C. Assessing the impact of some industrial and transport activities on soil by the global pollution index. *Environ. Eng. Manag. J.* **2011**, *10* (3), 387-391.
19. Zaharia, C. An environmental impact assessment applied for a unit of machine-tools manufacturing. *Proceeding of the 14th International Conference – Modern Technologies, Quality and Innovation – ModTech International Conference – New Face of T.M.C.R.,* May 20-22, Slanic Moldova **2010**, 687-690.
20. Mocanu, A.M.; Luca, C.; Odochian, L.; Zaharia, C.; Iordache, C. Assessment of environmental impact of some new aryloxyalkyl carboxilic acid derivatives. *Environ. Eng. Manag. J.* **2012**, *11* (2), 413-420.