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Evolution of Water Quality in Romania

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1. Introduction

Globally, water is a renewable natural resource, but vulnerable and limited, so it must be treated as a natural heritage to be protected and defended. In our century, one of the largest global problems concerning water management, taking into account that the population of the planet is in continuous growing, is the crisis of drinking water. The structure of water resources is mainly represented by freshwater, which is a rather small percentage of total water on the planet, namely 2.5%, while the percentage of 70% constitutes the water on the surface of the Earth. The fresh water is directly accessible by springs, rivers, lakes, and ground water, the rest being found in glacial ice. It means that only 0.7% of the planet's water is available, as a source of survival for the current population (Dodds, 2002; http://www.anpm.ro/ Mediu/rapoarte, accessed 2011).

For these reasons, conservation, water saving and reuse, and not at least water quality are serious problems that concerns all states. In order to preserve water resources an maintain water quality at best standards by protecting water quality and quantity, states policies are elaborated in order to encourage the above mentioned desiderates by the application of economic stimuli, and by imposing penalties for those wastes or pollute the water (Meybeck, 2004).

Concerning Romania's case, the authorities confront with the same concerns regarding water quality as all other states, water quality being affected by a wide range of natural and human influences. If human influences concern the result of economical and domestic activities, the natural influences are geological, hydrological, and climatic (Wake, 2005; Shirodkar et al., 2009; Bulut et al., 2010; Odagiu, 2010; Odagiu et al., 2010). The Romanian particularities in the field are conferred by national geographical and economical specific. In this respect, we have to mention that because of the climate changes, especially in recent years, leading to increased drought phenomena, must be taken in view the need to manage water resources in a special manner in order to preserve this resource for future generations (Dodds, 2002; Blenckner, 2005; http://www.anpm.ro/ Mediu/rapoarte, accessed 2011). Another aspect, which must be taken into consideration, is that both economical and social realities recorded in last decade, imposed a better understanding of water quality evolution at national level, in order to find useful solutions for prediction models and reducing pollutants inputs of a large variety of sources (industry, agriculture, etc.).

Water resources of Romania are made up of surface water - rivers, lakes, river Danube (~ 90%) -, and groundwater (~ 10%). The main water resource of Romania is the inland rivers. Theoretically speaking, total water resource in Romania was in 2009 of 136,600,000 thousand m3 while that existing, according to the degree of development of river basin, is 40,482,841 thousand m3 under the terms of a national requirement of 12,265,698 thousand m3 (http://www.anpm.ro/ Mediu/rapoarte, accessed 2011). Taking into account only the contribution of inland rivers, from this point of view our country may be included in the category of countries with relatively low water resources in relation to the resources of other countries.

Generally speaking, monitoring water quality represents the activity of observations and standardized measurements and continues long-term awareness and evaluation of the parameters characteristic of water for household chores and defining the status and trend of the evolution of their quality, as well as permanent highlighting condition of water resources (Hirsch et al., 2009; Goyal et al., 2010; Odagiu, 2010).

In Romania, the quality of water is monitored according to the structure and the methodological principles of Integrated Monitoring System of Wastewater in Romania (S.M.I.A.R.), restructured in accordance with the requirements of European Directives. The inventory of the water pollutants is performed at regional level, based on the information delivered by the inventoried economical operators and statistical data collected and processed by regional competent authorities. The national system for monitoring water comprises two types of monitoring, in accordance with legislative requirements in the area: monitoring of supervisors having the role of assessing the status of all bodies of water in the river basin and operational monitoring (integrated monitoring displays) for bodies of water which have a risk not to fulfil the objectives of water protection (Oroian&Petrescu–Mag, 2011; http://www.anpm.ro/ Mediu/rapoarte, accessed 2011).

For the evaluation of chemical water quality overall, in each section, were calculated for each indicator, mean values, and these were compared with the limit values of the quality classes set by norm with five quality categories, resulting employment in one of the five quality categories. The indicators included in the Order of the Ministry of the Environment and Forests no. 161/2006 approving the Norms on the classification of the quality of surface waters in order to establish the ecological status of water bodies, were divided into five main groups (Oroian&Petrescu–Mag, 2011; http://www.anpm.ro/ Mediu/rapoarte, accessed 2011):

- the group "oxygen", which includes: dissolved oxygen, BOD5, COD - Mn, COD - Cr;
- the group "nutrients", which includes: ammonium, nitrites, nitrates, total nitrogen, orthophosphates, total phosphorus, chlorophyll a;
- the group "general ions, salinity", which includes: filterable dry residue, sodium, calcium, magnesium, total iron, total manganese, chlorine, sulphates;
- the group "metals", that contains: zinc, copper, chromium, arsenic; metals such as lead, cadmium, mercury, nickel, were assigned to the group of priority substances;
- the group "organic and inorganic micro pollutants", which includes: phenols, detergents, AOX, petroleum hydrocarbons; other substances, such as PAH, PCB, DDT, lindane, atrazine, tetrachloromethane, trichloromethane, tetrachloroethane, etc. were assigned the group priority substances.

Emphasizing the evolution of surface water, wastewater and ground water quality in Romania for the period of 5 years between 2005 and 2009, and testing the multiregression analyze model in order to predict this evolution, are the main objectives of our study.

2. Data collection

Usually, monitoring the quality of water resources at national level cannot be performed by the measurement of only one parameter, because of many reasons. The water quality indices are variable in time and space, and this needs complex monitoring activity involving the measurement of a series of chemical physical and biological parameters according to special patterns, which are changing over time function of external conditions. Some of the above mentioned indicators provide general information concerning water pollution, whereas others enable the direct tracking of water pollution sources.

The data concerning the main water pollutants were collected from annual reports elaborated by regional authorities and from public data delivered by the reports of the Ministry of Environment and Forests, and annual environmental reports of the National Agency of Environmental Protection.

3. Statistics

Basic statistics, correlation and multivariate calculations were carried out in order to give initial information about the water quality data. Calculation of means, Pearson correlations, and multiple correlations were performed using STATISTICA 7.0 software for Windows. The calculation of Pearson correlation coefficients were performed in order to evaluate the correlations between the levels of variables (water virtual pollutants within surface water, groundwater and wastewater), and multiple regression analysis was conducted in order to evaluate the interrelation between chemical pollutants from surface water, groundwater and wastewater, and predict their future evolution. All tests of significance and correlations were considered statistically significant at P values of < 0.05, < 0.01, and < 0.001 (Blenckner, 2005; Sojka et al., 2008; Kazi et al., 2009; Papaioannou et al., 2010).

During the period of five years that concerns the data collection, processing and analyze, the management of water quality in Romania was conducted and practiced, by authorities, according to requirements of the following EU directives: 60/2000/CEE, 75/440/EEC, 76/464/EEC, 91/676/EEC, 78/659/EEC, and 91/271/EEC, adopted and/or transposed in Romanian legislation (Oroian&Petrescu-Mag, 2011). They concern usual physical, chemical and ecological water indicators.

The main water pollutants identified during the period of 5 years and all water categories (surface water, groundwater and wastewater) were: nitrogen compounds, chlorine, Fe, P, Fe, Mn, Cu, Cd, Zn, pesticides, oil products and detergents.

4. The quality of surface waters

The summary of the quality of surface waters by 2005 (Fig. 1a) was the result of processing the raw data deriving from the physico-chemical analyses of water sampled from 825 monitoring flowing water sections and 97 lakes (http://www.anpm.ro/Mediu/rapoarte, 2005,accessed 2011), and performed in accredited laboratories. It was distributed as follows: 31.40% Ist quality water, 46.10% IInd quality water, 15.80% IIIrd quality water, 3.70% IVth quality water, and 3.10% Vth quality water.

From the point of view of monitoring activities developed at large national scale, the main components of the surface water are the flowing water (rivers) and lakes (Mihăiescu et al., 2010). The results of monitoring activities performed on these water categories may be summarized for flowing water distribution by five qualities (Fig. 1b) as follows: 29.80% Ist quality water, 46.40% IInd quality water, 16.50% IIIrd quality water, 5.10% IVth quality water, and 2.20% Vth quality water. Concerning the lake water, it was distributed only by four qualities (Fig. 1c), the Vth quality water missing, as follows: 47.10% Ist quality water, 33.30% IInd quality water, 17.60% IIIrd quality water, and 2.00% IVth quality water.

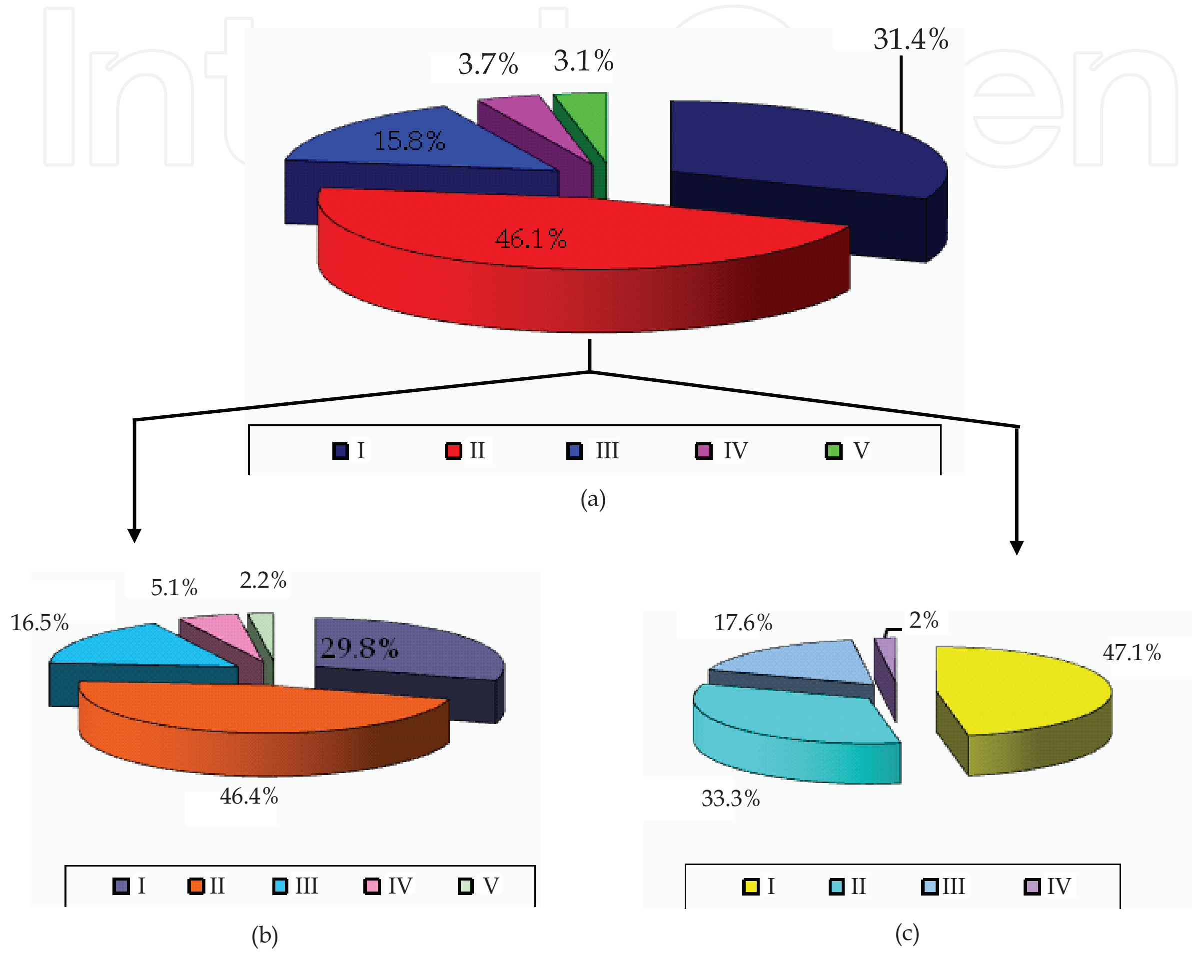

Fig. 1. (a) The surface water distribution by 5 qualities in 2005. (b) The flowing water distribution by 5 qualities in 2005 (c) The lake water distribution by 4 qualities in 2005

By 2006, the summary of the quality of surface waters (Fig. 2a) was, as the same as in 2005, the result of processing the raw data deriving from the physico-chemical analyses of water sampled from 825 monitoring flowing water sections and 102 lakes (http://www.anpm.ro/Mediu/rapoarte, 2006, accessed 2011). The results of the analysis demonstrates that the water quality was also divided by five categories, but the water of first quality was with 0.80% higher in this year, compared to previous: 25.80% Ist quality water, 41.50% IInd quality water, 17.20% IIIrd quality water, 12.10% IVth quality water, and 3.40% Vth quality water. The IVth and Vth quality water summarize 15.50%, and this represents a bigger share compared to 2005, when the share of the most polluted water at national scale was reported to be 6.80%.

The flowing water distribution, in 2006, by five qualities (Fig. 2b) was: 25.30% Ist quality water, 41.50% IInd quality water, 17.40% IIIrd quality water, 12.00% IVth quality water, and

3.80% Vth quality water. The share of the Ist quality water is with 4.50% smaller compared to previous year, while the share of low quality water (IVth and Vth) was 15.80%, also bigger (with 8.50%) compared to previous year (7.30%).

In this year, the lake water was distributed by five qualities (Fig. 2c) as follows: 22.30% Ist quality water, 47.10% IInd quality water, 15.20% IIIrd quality water, 9.00% IVth quality water, and 6.40% Vth quality water. We find that, in 2006, the lake water of low quality (IVth and Vth) occupies a bigger share (15.40%), compared to 2005, when Vth quality water was not reported, and IVth quality water represented only 2% from total analyzed lake water at national level, while the Ist quality water occupied a share with 23.80% smaller compared to 2005 (47.10%).

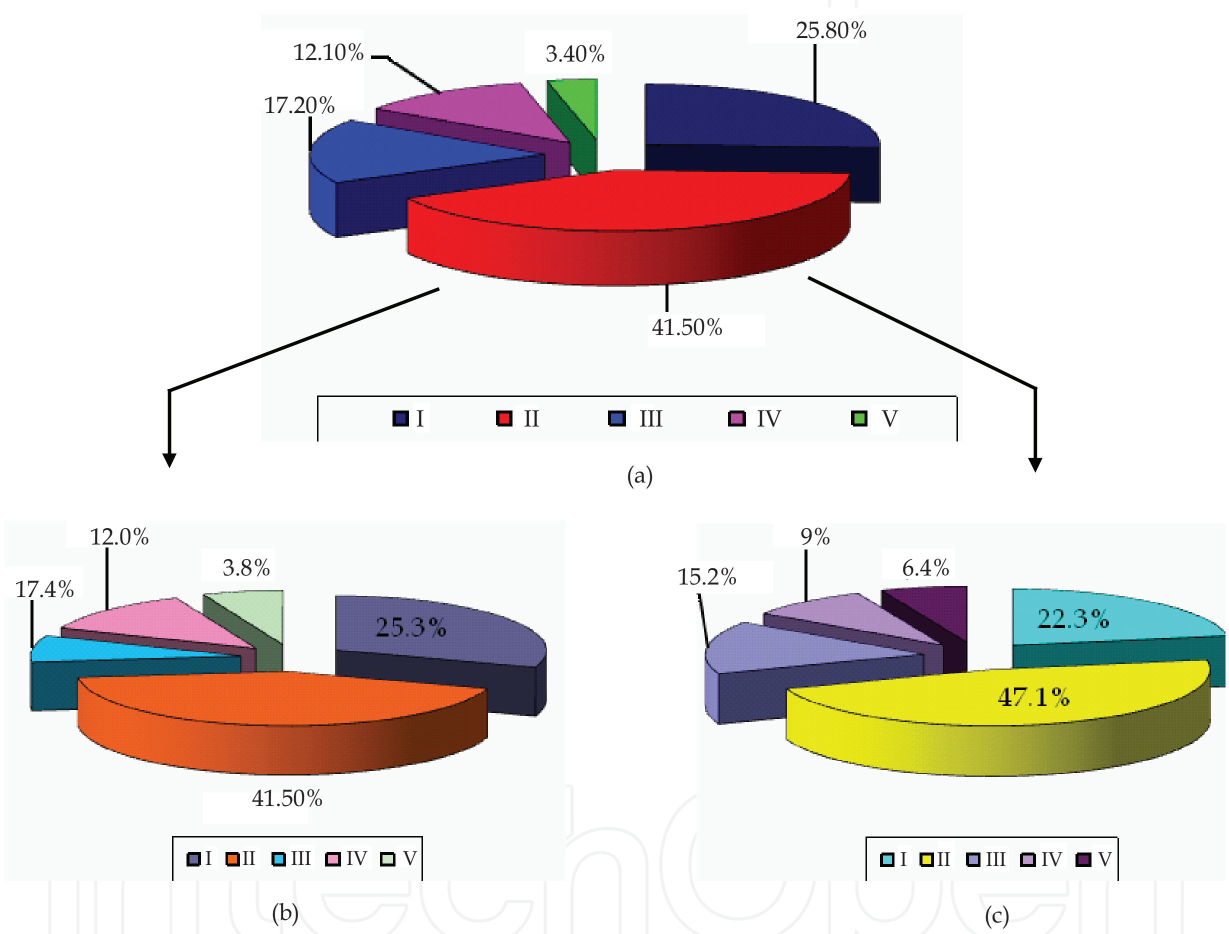

Fig. 2. (a) The surface water distribution by 5 qualities, in 2006. (b) The flowing water by 5 qualities, in 2006. (c) The lake water distribution by 5 qualities, in 2006

The same study, as for the years 2005 and 2006, was performed on 2007, and data reported for the summary of the quality of surface waters by 2007, (Fig. 3a) also resulted after processing the raw data deriving from the physico-chemical analyses of water sampled from almost the same numbers of flowing water sections and lakes, as previous years, 824 monitoring flowing water sections and 100 lakes, respectively (http://www.anpm.ro/Mediu/rapoarte, 2007, accessed 2011). The share of the Ist quality water was smaller in this year (23.80%) compared to previous years (which was bigger than 31%). The distribution of the surface water, lakes and rivers, in 2007, by quality categories may be summarized as follows: 23.80% Ist quality water, 45.00% IInd quality water, 18.80% IIIrd quality water, 7.90% IVth quality water, and 4.50% Vth quality water. For the low quality water (IVth and Vth) was reported a share of 12.40%, which means a bigger pollution of lake waters compared to 2005 (6.80%) but smaller compared with 2006 (15.50%).

Concerning the Romanian flowing water quality, in 2007, the National Agency for Environmental Protection reported the following distribution by five qualities (Fig. 3b): 23.40% Ist quality water, 44.50% IInd quality water, 21.30% IIIrd quality water, 7.20% IVth quality water, and 3.60% Vth quality water. The share of the Ist quality water, was in 2007 with 6.40% smaller compared to 2005, and with 1.90% compared to 2006. The same evolution was recorded concerning the IVth and Vth quality water, which was 10.80% from total monitored flowing waters, if the comparison is made with the values reported for 2005 (7.30%). If we report the low flowing water quality to 2007, we find that 5.00%variation was recorded (10.80% in 2007 compared to 15.80% in 2006).

The picture of lake water quality emphasize in 2007, the same distribution as in 2006, by five qualities (Fig. 3c), as follows: 45.00% Ist quality water, 27.00% IInd quality water, 13.00% IIIrd quality water, 11.00.00% IVth quality water, and 4.00% Vth quality water. The difference between the situation of Romanian lakes water quality in 2007 and previous years consists in smaller share (about 2%) of Ist quality water, compared to 2005 and 22.27%

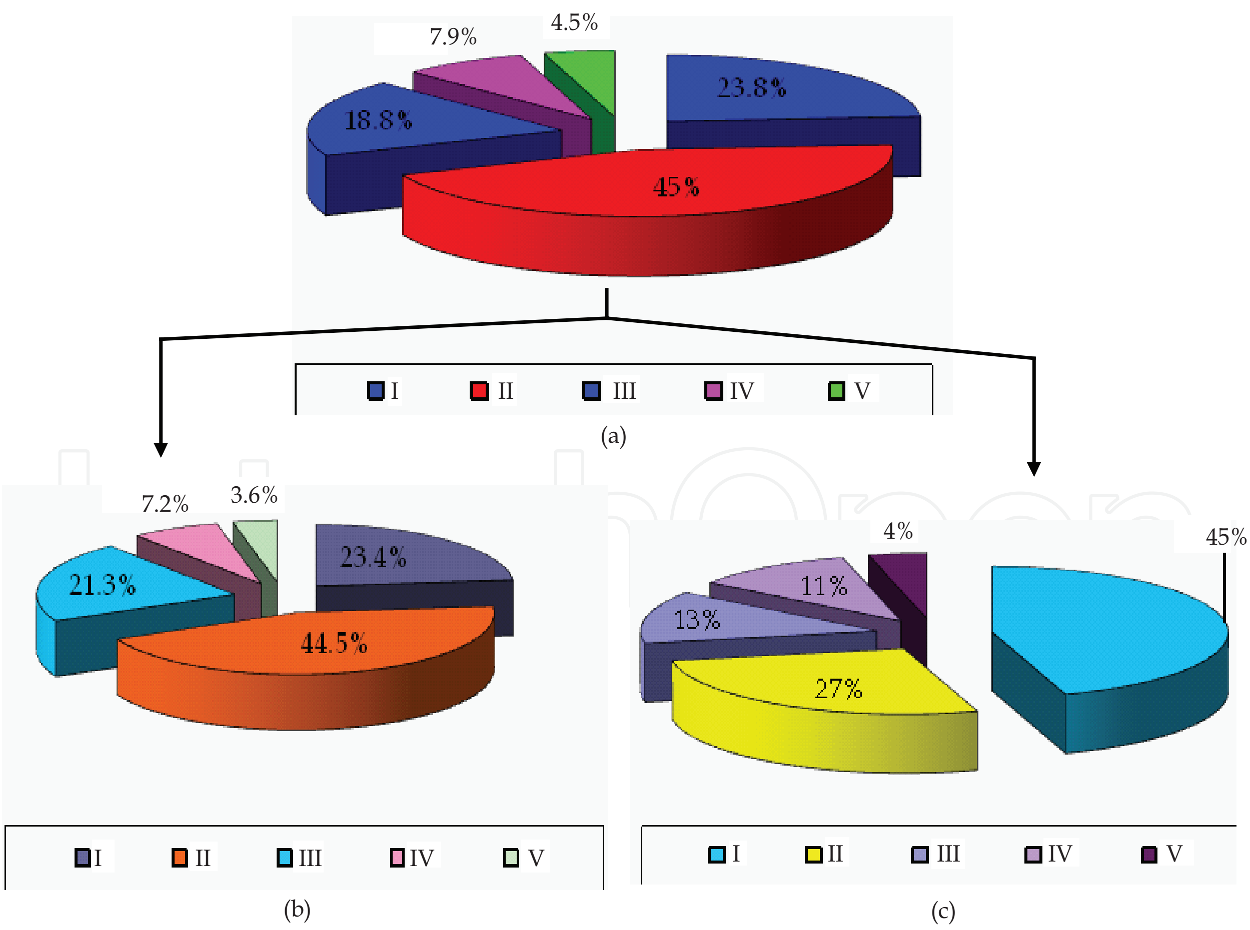

Fig. 3. (a) The surface water distribution by 5 qualities, in 2007. (b) The flowing water distribution by 5 qualities, in 2007. (c) The lake water distribution by 5 qualities, in 2007

compared to 2006, and much bigger concerning IVth and Vth quality water, which was 15.00% from total monitored lake waters, while in 2005 it was only 2% (Vth quality water was not reported), and 13.40% in 2006.

In 2008, the data concerning the summary of the quality of surface waters (Fig. 4a) was the result of processing the raw data deriving from the physico-chemical analyses of water sampled from 817 monitoring flowing water sections, less than previous years (825 in 2005 and 824 in 2006 and 2007) and 102 lakes. Globally, the quality of flowing water and lakes monitored at national level during the reference year 2008 was distributed as follows: 29.00% Ist quality water, 44.40% IInd quality water, 17.10% IIIrd quality water, 5.50% IVth quality water, and 3.90% Vth quality water (http://www.anpm.ro/Mediu/rapoarte, 2005, accessed 2011). Compared to 2007, the share of Ist quality water was bigger with more than 5%, and compared with 2006 with 3.20%, but if comparison is made with 2005, it was smaller (with 2.40%).

Concerning the flowing water, the distribution was by five qualities (Fig. 4b) as follows: 26.40% Ist quality water, 45.50% IInd quality water, 19.40% IIIrd quality water, 5.60% IVth quality water, and 3.10% Vth quality water. The most polluted water (IVth and Vth quality water) covered a share of 8.70%, less compared with 2007 (10.80%), and 2006 (15.80%), but more compared with 2005 (7.30%). For the Ist quality water was reported a bigger value

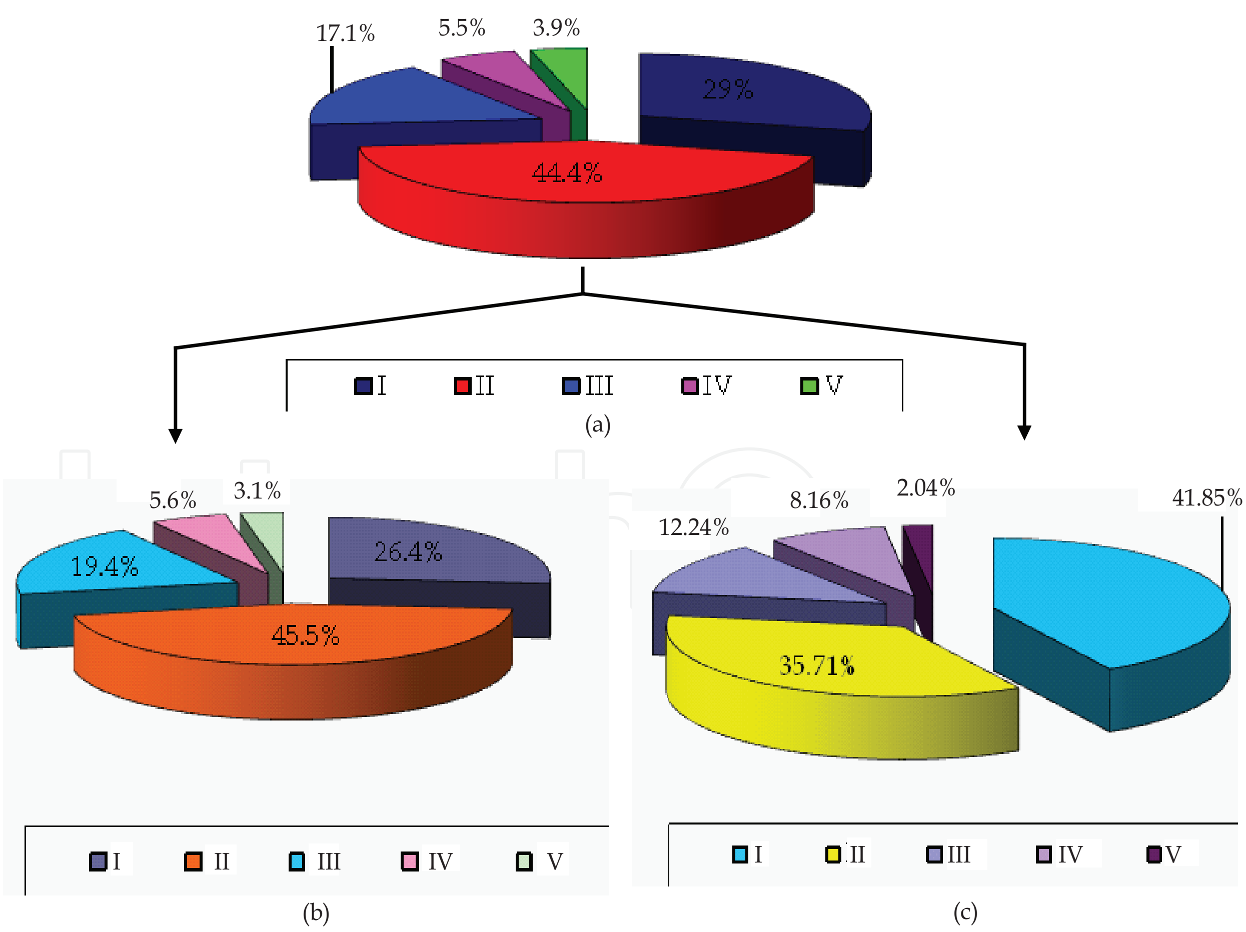

Fig. 4. (a) The surface water distribution by 5 qualities, in 2008 (b) The flowing water distribution by 5 qualities, in 2008. (c) The lake water distribution by 5 qualities, in 2008

compared with 2007 (with 3.00), and 2006 (with 1.10%) but smaller compared with 2005 (with 2.40%).

The water quality of the main lakes in Romania in relation to the water data analysis leads to the conclusion that out of the total of 102 (Fig. 4c), their water have different qualities, as follows: 41.85% Ist quality water, 35.71% IInd quality water, 12.24% IIIrd quality water, 8.16% IVth quality water, and 2.04% Vth quality water. The values concerning the Ist quality water, recorded in 2008, are bigger compared to 2006 (25.80%), but smaller compared with 2005 (47.10%), and 2007 (45.00%). Concerning the share of most polluted lakes (IVth and Vth quality water), their share was 10.20% in 2008, bigger compared to 2005 (2.00%), but smaller if comparison is made to 2006 and 2007, when the share of IVth and Vth quality water was reported as 15.80% and 15.00%, respectively.

In 2009, the data concerning the summary of the quality of surface waters (Fig. 5a) was the result of processing the raw data deriving from the physico-chemical analyses of water sampled from a similar number of monitoring flowing water sections as in 2008 (818 in 2009 compared to 817 in 2008), and 95 lakes. It was distributed as follows: 29.80% Ist quality water, 43.60% IInd quality water, 16.50% IIIrd quality water, 5.70% IVth quality water, and 4.30% Vth quality water (http://www.anpm.ro/Mediu/rapoarte, 2005, accessed 2011). The value of Ist quality water share was similar with 2008 (29.00%), and the same situation was also reported for IVth and Vth quality water.

The flowing water distribution by five qualities (Fig. 5b) was: 21.70% Ist quality water, 46.80% IInd quality water, 17.90% IIIrd quality water, 6.10% IVth quality water, and 3.50% Vth quality water. The share of the Ist quality flowing water in 2009 was the smallest reported for the period of 5 years we studied (29.80% in 2005, 25.80% in 2006, 23.40% in 2007, and 26.40% in 2008), while the share of 9.60% reported for IVth and Vth quality water was bigger compared to values reported in 2008 (8.70%) and 2005 (7.30%), but smaller compared to values reported in 2006 (15.80%), and 2007 (10.80%).

The water quality of the main lakes in Romania in relation to the water data analysis leads to the conclusion that out of the total of 95 (Fig. 5c), their water have different qualities, as follows: 34 had Ist quality water (35.80%), 42 had IInd quality water (44.21%), 14 had IIIrd quality water (14.70%), 4 had IVth quality water (4.20%), and 1 Vth quality water (1.10%). The share of the Ist quality lake water in 2009 (35.80%) was of bigger compared with 2006 (25.80%), but smaller compared to the other years of the analyzed period (47.10% in 2005, 45.00% in 2007, and 41.81% in 2008). The share of 5.30% reported for IVth and Vth quality water was bigger only compared to value reported in 2005 (2.00%), and smaller compared to values reported for the other analyzed years of the studied period (with 8.10% compared to 2006, with 9.70% compared to 2007, and with 4.90% compared to 2008).

If we study the distribution of monitored quality of surface waters in their assembly by entire 5 years studied period between years 2005 and 2009, by five qualities (Fig. 6) we find the evolution of its quality.

Thus, the biggest share of the Ist quality surface water was recorded in 2005 (31.40%), with similar values in 2008 (29.00%) and 2009 (29.80%), while the lowest value was recorded in 2007 (23.80%). For the IInd quality surface water there was reported the biggest share during entire studied period of five years, more than 40.00%. The biggest value was reported in 2005 (46.10%), with close values in 2007 (45.00%), and 2008 (44.40%), and smallest share in

2006 (41.50%). Concerning the IIIrd quality water, shares between 15.80% and 18.80% were reported during the studied monitoring period between 2005 and 2009. The biggest value of the IIIrd quality surface water was reported in 2007 (18.80%), while the smallest in 2005 (15.80%). Almost identical values were recorded in 2006 (17.20%), and 2008 (17.10%), while in 2009 a share of 16.50% was reported for the same surface water category.

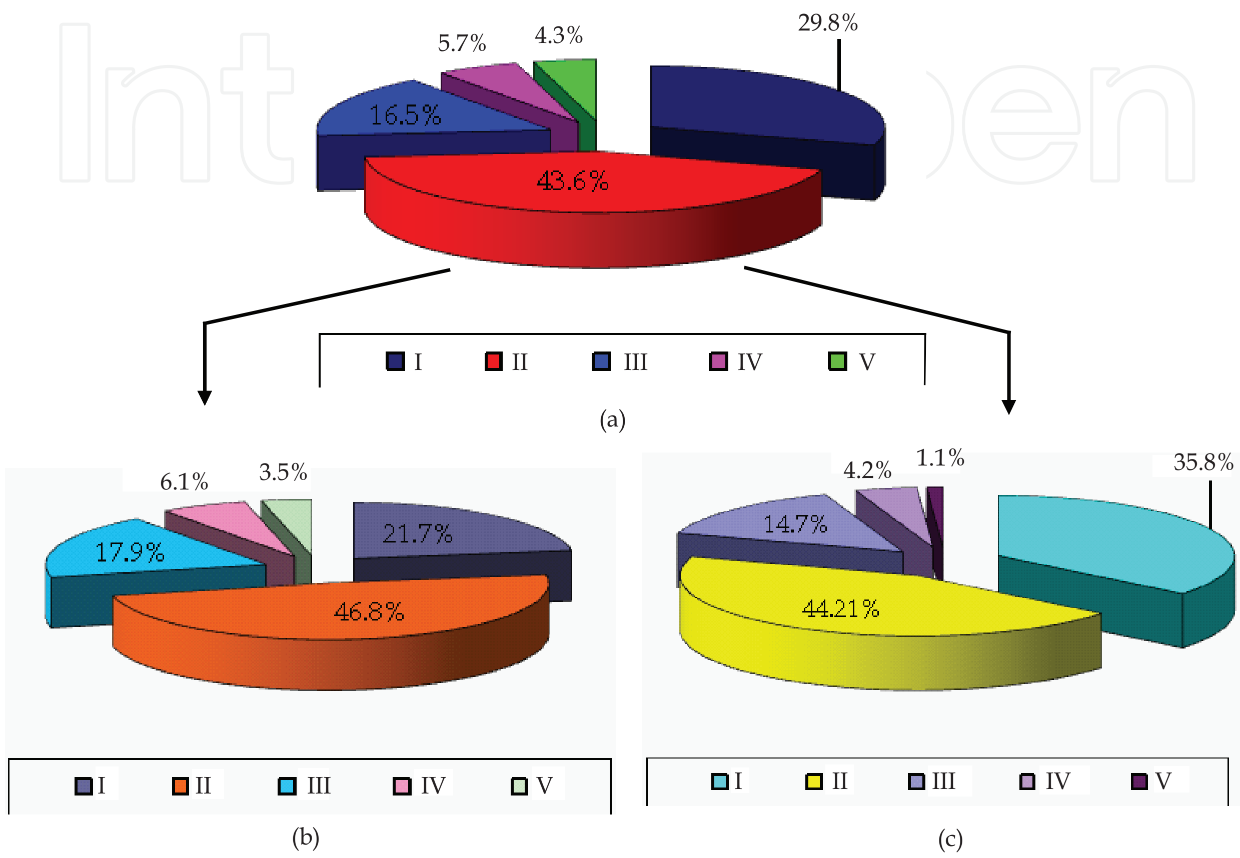

Fig. 5. (a) The surface water distribution by 5 qualities, in 2009 (b) The flowing water by 5 qualities, in 2009 (c) The lake water distribution by 5 qualities, in 2009

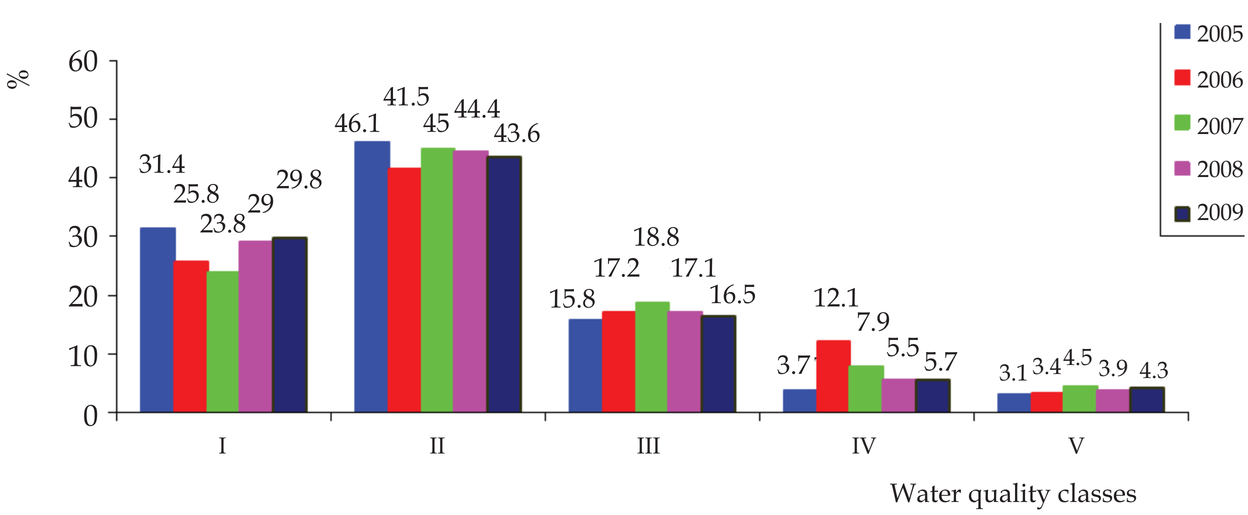

Fig. 6. The surface water distribution by 5 qualities, and by years, during the period of five years 2005 - 2009

The IVth quality surface water and Vth quality surface water represent the most polluted water category, with highest content in the main pollutants identified in the surface water (nitrogen compounds, chlorine, Fe, P, Fe, Mn, Cu, Cd, Zn, pesticides, oil products and detergents). The biggest values of the low quality surface water were recorded in 2006, 15.80 respectively, and the smallest in 2005, 6.80, respectively. The values of the IVth and Vth quality surface water reported in the other years of the studied period of 5 years (2005 – 2009) were: 12.40% in 2007, 9.40% in 2008, and 10.00% in 2009.

5. The quality of groundwater

It was emphasized that the natural groundwater regime has suffered over time, a number of quantitative and qualitative changes. These changes are due both to their use as a source of drinking water supply, execution of industrial and construction of water projects and hydrological improvements, and polluting factors (natural and antropic). Groundwater bodies are classified in two classes: good and poor, for both quantitative and chemical status. For the assessment of groundwater chemical status, the concentrations determined at the point of monitoring laid down in accordance with the water framework directive is compared with threshold values (TV) which are regarded as self-defence for good status of groundwater body.

In 2005 there were monitored a number of 1,947 drilling places, of which 1,664 are belonging to the national network and 283 are drillings performed with the aim of tracking pollution located around major industrial centres. From the analysis of the processed data consisting in physical and chemical parameters resulted from monitoring phreatic layer located in above mentioned drillings, most values over thresholds have been recorded for the indicators: organic substances, ammonium, nitrates, phosphates, and iron. Thus in 580 of analyzed drillings, values over thresholds were registered in organic substance; in 450 drillings, values over thresholds for nitrates, and in 85 drillings, for phosphates.

In 2006 there were monitored the same number of drilling places, 1,947 respectively, of which 1,664 are belonging to the national network and 283 are drillings performed with the aim of tracking pollution located around major industrial centres. From the analysis of the processed data consisting in physical and chemical parameters resulted from monitoring phreatic layer located in above mentioned drillings, most concerning have been recorded for the indicators: organic substances, ammonium, nitrates, phosphates, iron. Thus in 543 of analyzed drillings (30.00%) values over thresholds were registered in organic substance; in 437 drillings (22.40%) values over thresholds for nitrates, and in 78 drillings (4.00%) for phosphates. Compared with the previous year, in 2006 it was shown a trend of decrease of aquifers contamination with these substances, in overall.

In 2007, the drillings were monitored taking into consideration the new system for groundwater monitoring, implemented in 2006, which pursues closer and more concrete supervision in terms of water quality. In 2007 were monitored a number of 1,939 drillings, of which 1.687 are part of national hydro geological network (of which 28 are springs) and 252 are drillings performed in order to tracking pollution, located around major industrial centres. From the analysis of the processed data resulted as consequence of monitoring the physical and chemical parameters of the phreatic layer located in drillings, most values over the established thresholds concerned: organic substances, nitrogen, ammonium, phosphates, and iron.

In 2008, there have been monitored 1,899 drillings. Through the county public Health Offices, there were also monitored fountains, whose water is generally non-drinking, because of the overshoot recorded for ammonium, nitrates, and bacteriological indicators. These, fountains and are infested by infiltrations from non hydro - isolated sanitation groups, and from domestic waste and animal origin waste, originating in private households. From the analysis of the processed data resulted as consequence of monitoring the physical and chemical parameters of the phreatic layer located in drillings, most values over the established thresholds concerned: organic substances, nitrogen, ammonium, total hardness, chlorine, phosphates, and iron. Concerning the groundwater contamination with nitrates, overshoot of concentration has been recorded in 220 drillings, what represents 11.59% of total drillings monitored. Pollution is differentiated felt, existing areas in majority of river basin, in which, in the aquifer are found concentrations that lie far above the limit allowed, 50 mg/L. Another cause of unsatisfactory groundwater quality is the intense contamination of aquifers with ammonium and organic substances. Thus, in 466 of analysed drillings, values over threshold were recorded for the organic substance, and in 518 drillings, the ammonium indicator had values over admitted threshold.

In 2009, for the assessment of the quantitative status of bodies of groundwater it has been used the European Guide recommendations, prepared in the framework of the Common Implementation Strategy Framework, using the following criteria: hydric balance; connection with surface waters; influence on terrestrial ecosystems dependent on groundwater, intrusion of saline water or other intrusions. The good status of groundwater, involves a number of conditions set out in annex V of the Water Framework Directive (Directive 2000/60/EC). Additional conditions for chemical status and evaluation procedures are developed in the Groundwater Daughter Directive (Directive 2006/118/EC), transposed into national law by Governmental Decision no. 53/2009, for the approval of the national plan of groundwater protection against pollution and deterioration.

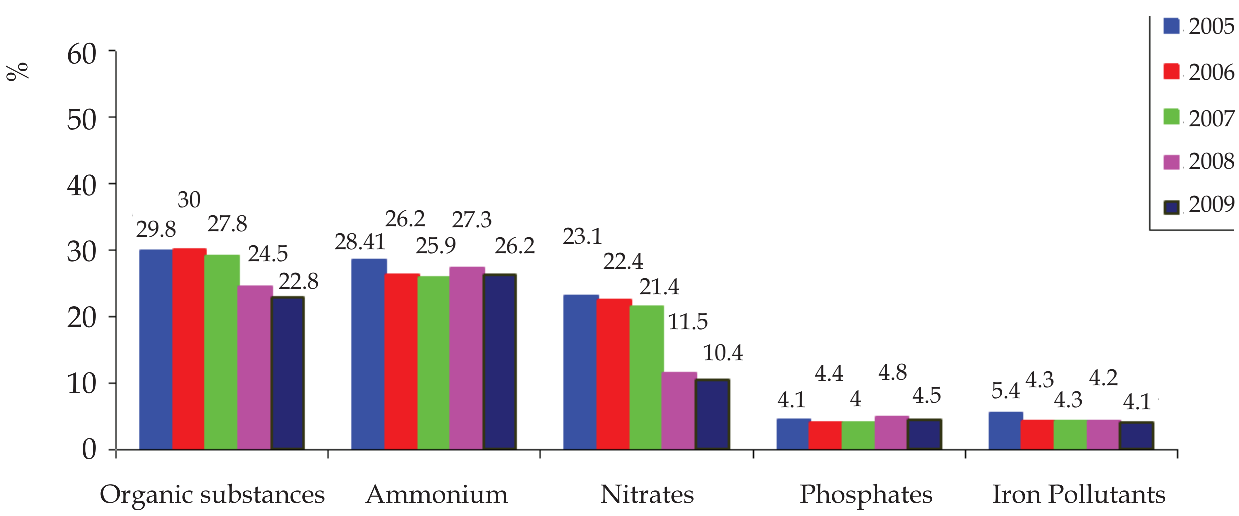

Fig. 7. The evolution of groundwater pollutants during studied five years period 2005 - 2009

Assessment of the status of bodies of groundwater was compiled on the basis of the comparison of chemical analysis carried out in 2009, with the threshold values (TV), values that have been determined for a number of 142 bodies of groundwater, from the 142 bodies established in Romania and which were published in the Order of the Ministry of Environment and Forests no. 137/2009. By applying the methodology and criteria for the assessment of groundwater bodies, the situation of those qualitative 142 bodies of groundwater shall be presented as follows: 109 bodies are in a good quality, 22 of groundwater bodies are in a poor quality, while 11 groundwater bodies are in a poor quality, locally.

6. The status of the wastewater

Insufficiently purified or even not at all purified wastewater discharge is one of the main causes of pollution and degradation of surface waters. Therefore, the main practical measures for the protection of the quality of surface waters is the purification of wastewater, which is collected and processed by a sewage system by sewage station, from where, as a rule, then are returned to the emissary.

The largest volumes of not purified and/or insufficiently purified wastewater resulted from units of the communal areas: households, heat and power plants, chemical processing, and then smaller volumes from units in the areas of trade and services for the population and from the extractive industry. Related to potential pollution, the highest share belongs to the fields of communal enterprises, and thermal electricity industry, extractive industry followed by businesses in the chemical industry, metallurgical, etc.

In 2005, the results of the monitoring activity performed on the main sources of wastewater, revealed the following realities: toward a total volume of the evacuated 3,886.126 million m3/year, 1,944.389 million m3/year, meaning 50.03%, is part of the waste water to be purified. Of the total volume of wastewater requiring treatment, 1,944.389 million m3/year, respectively, a volume of 351.400 million m3/year, (18.07%), was sufficiently purified (as scheduled). Otherwise 660.634 million m3/year, (about 34.9%), are not purified wastewater, and 848.482 million m3/year, about 44.9%, not completely purified wastewater. So, in 2006, about 79.8% of not or insufficiently purified wastewaters from the main sources of pollution, have reached the natural receptors, especially rivers. Compared with the total number of 1,035 investigated purification stations, installations, only 274 stations, representing 26.5%, have functioned properly, and the rest of 761 (73.5%) operated improperly.

The statistical analysis of the main sources of wastewater, according to the results of the monitoring activity carried out in 2006, revealed the following global issues: toward a total volume of the evacuated 3,586.126 million m3/year, 1,891.622 million m3/year, meaning 52,7%, is part of the waste water to be purified. Of the total volume of wastewater requiring treatment, 1,891.622 million m3/year, respectively, a volume of 382.506 million m3/year, (20.2%), was sufficiently purified (as scheduled). Otherwise 660.634 million m3/year, (about 34.9%), are not purified wastewater, and 848.482 million m3/year, about 44.9%, not completely purified wastewater. So, in 2006, about 79.8% of not or insufficiently purified wastewaters from the main sources of pollution, have reached the natural receptors, especially rivers. Compared with the total number of 1,035 investigated purification stations, only 274 stations, representing 26.5%, have functioned properly, and the rest of 761 (73.5%) operated improperly.

The statistical analysis of the main sources of wastewater, according to the results of the monitoring activity carried out in 2007, revealed the following global issues: toward a total volume of the evacuated 4,985..065 million m3/year, 2,210.285 million m3/year, meaning 44.30%, is part of the waste water to be 498.668.506 million m3/year, (22.60%), was sufficiently purified (as scheduled). Otherwise 791.320 million m3/year, (about 35.80%), are not purified wastewater, and 919.083 million m3/year, about 41.60%, not completely purified wastewater. So, in 2007, about 77.40% of not or insufficiently purified wastewaters from the main sources of pollution, have reached the natural receptors, especially rivers. Compared with the total number of 1,348 investigated purification stations, only 410 stations, representing 30.40%, have functioned properly. The remaining 938 stations (69.60%) operated improperly, because of not enough treatment capacity, or due to the operating and maintenance problems (advanced physical and moral wear inefficiency of the biological treatment phase concerning the insurance of needed oxygen, lack of investments for modernization, etc).

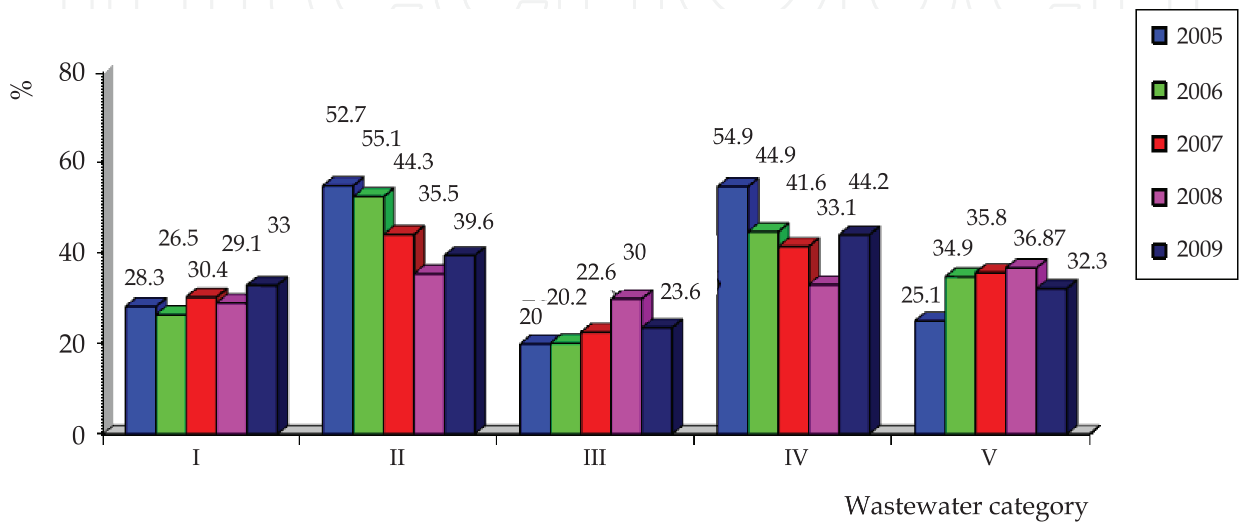

Fig. 8. The evolution of the wastewater categories during studied period of 5 years 2005 – 2009. I – water resulted from purification stations that functioned properly; II – wastewater to be purified; III – wastewater sufficiently purified (corresponding); IV – wastewater insufficiently purified; V – wastewater not purified

Compared with the total refused volume 5,254.565 million m3/year, 1,868.832 million m3/year (35.57% of the total) were wastewater to be purified. Of these, 560.623 million m3/year (30%) were sufficiently purified (corresponding), 689.145 million m3/year (36,87%) have been insufficiently purified wastewater and 619.064 million m3/year (33.13%) were not purified wastewater. Therefore, in 2008, a rate of 70% of wastewaters, not purified or insufficiently purified, from the main sources of pollution, has reached the natural receptors, especially rivers.

Statistical analysis of the situation of the main sources of waste water, according to the results of the monitoring carried out in 2009, revealed the global issues that are described below. Compared with the total volume of the refused water - 5,206.207 million m3/year, 2,058.899 millions m3/year (39.6% of the total) are wastewater to be purified. Of these, 485.438 million m3/year (23.60%) were sufficiently purified (corresponding), 909.019 millions m3/year (44.2%) were insufficiently purified wastewater and 664.442 million m3/year (32.2%) were not purified wastewater. Therefore, in 2009, 76.5% of not purified or insufficiently purified wastewaters from the main sources of pollution have reached the natural receptors, especially rivers. Compared with the total number of 1.363 investigated (urban and industrial) purification stations, only 445 stations, accounting for 33%, have functioned properly, and the remaining 9 stations, namely 67% operated improperly.

7. Correlations

In order to measure and establish the relationships between variables representing the main pollutants (nitrogen compounds, phosphates, Cl, S, Pb, Cd, Hg, As, oil products, pesticides) of the monitored groundwater, monitored surface water (Cu, Cd, Mg, and Zn), in Romania during analyzed five years period, the correlation coefficients were calculated.

7.1 Correlations between main pollutants of surface water

Very strong (0.858 – 0.921) and very significant correlations ($P < 0.001$) were identified, in 2005, between Cu, Cd, Mg, and Zn pollutants in surface water (Table 1), and according to the average value of the determination coefficient, 87.50% of our data conform to the linear relationship.

Issue	Cu (mg/L)	Cd (mg/L)	Mg (mg/L)	Zn (mg/L)
Cu (mg/L)	1.000	0.858***	0.892***	0.893***
Cd (mg/L)		1.000	0.867***	0.921***
Mg (mg/L)			1.000	0.889***
Zn (mg/L)				1.000

*R^2 = 0.875

Table 1. The correlation matrix *between metallic pollutants of surface water in 2005

Very strong (0.872 – 0.911) and very significant correlations ($P < 0.001$) were identified between Cu, Cd, Mg, and Zn pollutants in surface water (Table 2), and according to the average value of the determination coefficient, 89.10% of our data conform to the linear relationship.

Issue	Cu (mg/L)	Cd (mg/L)	Mg (mg/L)	Zn (mg/L)
Cu (mg/L)	1.000	0.872***	0.887***	0.897***
Cd (mg/L)		1.000	0.891***	0.911***
Mg (mg/L)			1.000	0.891***
Zn (mg/L)				1.000

*R^2 = 0.891

Table 2. The correlation matrix *between main pollutant components of surface water in 2006

Issue	Cu (mg/L)	Cd (mg/L)	Mg (mg/L)	Zn (mg/L)
Cu (mg/L)	1.000	0.858***	0.892***	0.863***
Cd (mg/L)		1.000	0.867***	0.921***
Mg (mg/L)			1.000	0.889***
Zn (mg/L)				1.000

*R^2 = 0.882

Table 3. The correlation matrix *between main pollutant components of surface water in 2007

In 2007, the relationship between Cu, Cd, Mg, and Zn pollutants in surface water (Table 3) was the same as those reported in previous years of the studied period (2005 – 2009). Between them was calculated very strong (0.858 – 0.921) and very significant correlations ($P < 0.001$) were identified between and according to the average value of the determination coefficient, 88.20% of our data conform to the linear relationship.

The correlation coefficients emphasized between Cu, Cd, Mg, and Zn pollutants in surface water by 2008 (Table 4), were positive very strong (0.861 – 0.918) and very significant ($P < 0.001$). The calculated average value of the determination coefficient justifies 88.60% the conformity of our data with the linear relationship.

Similarly with previous years of analyzed period of five years (2005 – 2009), the calculated correlations between the main metallic pollutants (Cu, Cd, Mg, and Zn) of the surface water in the last year of the studied interval of time, 2009, respectively (Table 5), revealed very strong (0.868 – 0.908) and very significant values ($P < 0.001$). The average value of the determination coefficient, 89.00% of our data conform to the linear relationship.

Issue	Cu (mg/L)	Cd (mg/L)	Mg (mg/L)	Zn (mg/L)
Cu (mg/L)	1.000	0.861***	0.899***	0.869***
Cd (mg/L)		1.000	0.875***	0.918***
Mg (mg/L)			1.000	0.895***
Zn (mg/L)				1.000

*$R^2 = 0.886$

Table 4. The correlation matrix* for main pollutant components of surface water data, in 2008

Issue	Cu (mg/L)	Cd (mg/L)	Mg (mg/L)	Zn (mg/L)
Cu (mg/L)	1.000	0.899***	0.898***	0.868***
Cd (mg/L)		1.000	0.893***	0.908***
Mg (mg/L)			1.000	0.875***
Zn (mg/L)				1.000

*$R^2 = 0.890$

Table 5. The correlation matrix*between main pollutant components of surface water in 2009

7.2 Correlations between main pollutants of groundwater

In groundwater, by 2005 (Table 6), very strong positive correlations, statistically very significant ($P < 0.001$) were identified between phosphates and nitrogen compounds (0.905; $R^2 = 0.819$), and also between Cl, S, Pb, Cd, Hg, As, oil products, pesticides (0.922 – 0.793), with an average $R^2 = 0.797$. Weak positive correlations, statistically not significant ($P > 0.05$) were identified between Cd, As, oil products, pesticides and phosphates, and also between Cl, S, Pb, Cd, Hg, As, oil products, pesticides and nitrogen compounds (Table 6). Average positive correlations were calculated between Cl and nitrogen compounds, statistically distinct significant ($P < 0.01$), and significant ($P < 0.05$) for S, Pb, Hg and nitrogen compounds, respectively (Table 6).

In 2006 (Table 7), too, very strong positive correlations, statistically very significant ($P < 0.001$) were identified between phosphates and nitrogen compounds identified in groundwater (0.912; $R^2 = 0.831$), and between Cl, S, Pb, Cd, Hg, As, oil products, pesticides (0.923 – 0.791), with an average $R^2 = 0.821$. Weak positive correlations, statistically not significant ($P > 0.05$) were identified between Cl, S, Pb, Cd, Hg, As, oil products, pesticides and phosphates (0.195 – 0.439), and also between S, Cd, Hg, As, oil products, pesticides and nitrogen compounds (0.354 – 0.498) while between Cl and nitrogen compounds was identified a positive (0.528) statistically significant moderate correlation ($P < 0.05$), and between Pb and nitrogen a statistically distinct significant ($P < 0.01$) moderate correlation coefficient of 0.583 (Table 7).

Issue	Nitrogen compounds	Phosphates	Cl	S	Pb	Cd	Hg	As	Oil products	Pesticides
Nitrogen compounds	1.000	0.905^{***}	0.654^{**}	0.543^{*}	0.553^{*}	0.412^{ns}	0.423^{*}	0.315^{ns}	0.413^{ns}	0.523^{ns}
Phosphates		1.000	0.250^{ns}	0.191^{ns}	0.278^{ns}	0.314^{ns}	0.322^{ns}	0.273^{ns}	0.389^{ns}	0.412^{ns}
Cl			1.000	0.793^{***}	0.812^{***}	0.845^{***}	0.889^{***}	0.878^{***}	0.909^{***}	0.913^{***}
S				1.000	0.832^{***}	0.891^{***}	0.799^{**}	0.803^{***}	0.903^{***}	0.886^{***}
Pb					1.000	0.872^{***}	0.923^{***}	0.925^{***}	0.904^{***}	0.796^{***}
Cd						1.000	0.893^{***}	0.835^{***}	0.902^{***}	0.798^{***}
Hg							1.000	0.887^{***}	0.908^{***}	0.825^{***}
As								1.000	0.895^{***}	0.805^{***}
Oil products									1.000	0.922^{***}
Pesticides										1.000

Table 6. The correlation matrix between main pollutant components of groundwater in 2005 (mg/L)

Issue	Nitrogen compounds	Phosphates	Cl	S	Pb	Cd	Hg	As	Oil products	Pesticides
Nitrogen compounds	1.000	0.912^{***}	0.528^{*}	0.432^{ns}	0.583^{**}	0.468^{ns}	0.381^{ns}	0.354^{ns}	0.462^{ns}	0.498^{ns}
Phosphates		1.000	0.195^{ns}	0.254^{ns}	0.259^{ns}	0.385^{ns}	0.364^{ns}	0.228^{ns}	0.315^{ns}	0.439^{ns}
Cl			1.000	0.791^{***}	0.812^{***}	0.845^{***}	0.889^{***}	0.878^{***}	0.909^{***}	0.913^{***}
S				1.000	0.832^{***}	0.891^{***}	0.799^{***}	0.803^{***}	0.913^{***}	0.886^{***}
Pb					1.000	0.872^{***}	0.923^{***}	0.915^{***}	0.914^{***}	0.796^{***}
Cd						1.000	0.893^{***}	0.835^{***}	0.912^{***}	0.798^{***}
Hg							1.000	0.887^{***}	0.918^{***}	0.825^{***}
As								1.000	0.895^{***}	0.805^{***}
Oil products									1.000	0.921^{***}
Pesticides										1.000

Table 7. The correlation matrix between main pollutant components of groundwater in 2006 (mg/L)

In the same year, 2007, in groundwater (Table 8), very strong positive correlations, statistically very significant ($P < 0.001$) were identified between phosphates and nitrogen compounds (0.915; $R^2 = 0.837$), and also between Cl, S, Pb, Cd, Hg, As, oil products, pesticides (0.920 – 0.798), with an average $R^2 = 0.803$. Weak positive correlations, statistically not significant ($P > 0.05$) were identified between Cl, S, Pb, Cd, Hg, As, oil products, pesticides and phosphates (0.182 – 0.422), and also between Cd, Hg, As, oil products and nitrogen compounds (0.322 – 0.457) while between S, Pb and nitrogen compounds were identified positive (0.525 and 0.541, respectively) statistically significant moderate correlation ($P < 0.05$), and between Cl and nitrogen a statistically distinct significant ($P < 0.01$) moderate correlation coefficient of 0.633 (Table 8).

Issue	Nitrogen compounds	Phosphates	Cl	S	Pb	Cd	Hg	As	Oil products	Pesticides
Nitrogen compounds	1.000	0.915^{***}	0.633^{**}	0.525^{*}	0.541^{*}	0.432^{ns}	0.457^{ns}	0.322^{ns}	0.405^{ns}	0.521^{*}
Phosphates		1.000	0.214^{ns}	0.182^{ns}	0.233^{ns}	0.366^{ns}	0.322^{ns}	0.281^{ns}	0.383^{ns}	0.422^{ns}
Cl			1.000	0.799^{***}	0.868^{***}	0.858^{***}	0.889^{***}	0.894^{***}	0.905^{***}	0.915^{***}
S				1.000	0.829^{***}	0.883^{***}	0.799^{***}	0.812^{***}	0.920^{***}	0.899^{***}
Pb					1.000	0.865^{***}	0.913^{***}	0.921^{***}	0.912^{***}	0.798^{***}
Cd						1.000	0.893^{***}	0.837^{***}	0.921^{***}	0.865^{**}
Hg							1.000	0.897^{***}	0.909^{***}	0.828^{***}
As								1.000	0.896^{***}	0.831^{***}
Oil products									1.000	0.914^{***}
Pesticides										1.000

Table 8. The correlation matrix between main pollutant components of groundwater in 2007 (mg/L)

Issue	Nitrogen compounds	Phosphates	Cl	S	Pb	Cd	Hg	As	Oil products	Pesticides
Nitrogen compounds	1.000	0.925^{***}	0.654^{**}	0.543^{*}	0.553^{*}	0.412^{ns}	0.423^{ns}	0.315^{ns}	0.413^{ns}	0.523^{*}
Phosphates		1.000	0.250^{ns}	0.191^{ns}	0.278^{ns}	0.314^{ns}	0.322^{ns}	0.273^{ns}	0.389^{ns}	0.412^{ns}
Cl			1.000	0.786^{***}	0.812^{***}	0.845^{***}	0.889^{***}	0.878^{***}	0.909^{***}	0.913^{***}
S				1.000	0.832^{***}	0.891^{***}	0.799^{***}	0.803^{***}	0.920^{***}	0.886^{***}
Pb					1.000	0.872^{***}	0.921^{***}	0.975^{***}	0.904^{***}	0.796^{***}
Cd						1.000	0.893^{***}	0.835^{***}	0.912^{***}	0.798^{***}
Hg							1.000	0.887^{***}	0.918^{***}	0.825^{***}
As								1.000	0.895^{***}	0.805^{***}
Oil products									1.000	0.912^{***}
Pesticides										1.000

Table 9. The correlation matrix between main pollutant components of groundwater in 2008 (mg/L)

In groundwater, by 2008 (Table 9), very strong positive correlations, and statistically very significant ($P < 0.001$) were identified between phosphates and nitrogen compounds (0.925; $R^2 = 0.856$), and also between Cl, S, Pb, Cd, Hg, As, oil products, pesticides (0.921 – 0.786), with an average $R^2 = 0.785$. Weak positive correlations, statistically not significant ($P > 0.05$) were identified between Cl, S, Pb, Cd, Hg, As, oil products, pesticides and phosphates (0.191 – 0.412), and also between Cd, Hg, As, oil products and nitrogen compounds, with values within the interval 0.315 – 0.423 (Table 9). Average positive correlations were calculated between Cl and nitrogen compounds (0.654), statistically distinct significant ($P < 0.01$). Between S, Pb, pesticides and nitrogen compounds were identified average correlation coefficients statistically significant ($P < 0.05$), with values within the interval 0.523 – 0.553 (Table 9).

Issue	Nitrogen compounds	Phosphates	Cl	S	Pb	Cd	Hg	As	Oil products	Pesticides
Nitrogen compounds	1.000	0.917^{***}	0.629^{**}	0.558^{*}	0.541^{*}	0.426^{ns}	0.453^{ns}	0.298^{ns}	0.432^{ns}	0.511^{*}
Phosphates		1.000	0.217^{ns}	0.185^{ns}	0.238^{ns}	0.325^{ns}	0.388^{ns}	0.235^{ns}	0.325^{ns}	0.461^{ns}
Cl			1.000	0.795^{***}	0.856^{***}	0.865^{***}	0.845^{***}	0.835^{***}	0.917^{***}	0.920^{***}
S				1.000	0.825^{***}	0.887^{***}	0.811^{***}	0.822^{***}	0.911^{***}	0.921^{***}
Pb					1.000	0.869^{***}	0.901^{***}	0.905^{***}	0.908^{***}	0.799^{***}
Cd						1.000	0.900^{***}	0.847^{***}	0.920^{***}	0.816^{***}
Hg							1.000	0.891^{***}	0.915^{***}	0.836^{***}
As								1.000	0.887^{***}	0.827^{***}
Oil products									1.000	0.921^{***}
Pesticides										1.000

Table 10. The correlation matrix between main pollutant components of groundwater in 2009 (mg/L)

The correlation coefficients calculated in 2009 for the groundwater pollutants (Table 10), revealed very strong positive correlations, statistically very significant ($P < 0.001$) between phosphates and nitrogen compounds (0.917; $R^2 = 0.841$), and also between Cl, S, Pb, Cd, Hg, As, oil products, pesticides (0.921 – 0.795), with an average $R^2 = 0.783$. Weak positive correlations, statistically not significant ($P > 0.05$) were identified between Cl, S, Pb, Cd, Hg, As, oil products, pesticides and phosphates (0.185 – 0.461), and also between Cd, Hg, As, oil products and nitrogen compounds (0.298 – 0.453), while between Cl and nitrogen compounds, statistically distinct significant ($P < 0.01$) correlation was found (0.629), and average positive correlations (0.558, and 0.629 respectively), statistically significant ($P < 0.05$), between S, Pb and nitrogen compounds (Table 9).

8. The multiregression analyze

Correlations were also calculated between main pollutants of: surface water and ground water, surface water and wastewater, ground water and wastewater. Their values (0.695 ÷ 0,986) emphasize the strong interdependence between pollutants matrices. The correlations calculated between the main pollutants identified in national water supply during a five years period, 2005 – 2009, deliver a complex picture of the water quality in Romania. Surface water quality is most affected by the discharge of untreated or inadequately treated sewage. In this context, a key measure to protect surface water quality is to increase wastewater treatment, upgrading and improving the cleaning process (tables 11 – 15).

Issue	Groundwater												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Surface water													
I	0.983												
II		0.857											
III			0.899										
IV				0.856									
V					0.932								
VI						0.986							
VII							0.956						
VIII								0.973					
IX									0.956				
X										0.888			
XI											0.867		
XII												0.829	
XIII													0.863
Waste water													
I	0.735												
II		0.699											
III			0.695										
IV				0.803									
V					0.788								
VI						0.695							
VII							0.743						
VIII								0.739					
IX									0.788				
X										0.803			
XI											0.768		
XII												0.731	
XIII													0.744

I – Nitrogen compounds; II – Phosphates; III – Cu; IV – Cd; V - Mn; VI – Zn; VII – Cl; VIII – S; IX – Pb; X – Hg; XI – As; XII - oil products; XIII - pesticides

Table 11. The correlation matrix between main pollutant components of surface water, groundwater and wastewater in 2005

Issue	Groundwater												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Surface water													
I	0.977												
II		0.869											
III			0.903										
IV				0.835									
V					0.955								
VI						0.932							
VII							0.947						
VIII								0.961					
IX									0.924				
X										0.835			
XI											0.858		
XII												0.845	
XIII													0.821
Waste water													
I	0.733												
II		0.701											
III			0.733										
IV				0.783									
V					0.781								
VI						0.791							
VII							0.725						
VIII								0.767					
IX									0.731				
X										0.784			
XI											0.772		
XII												0.739	
XIII													0.751

I – Nitrogen compounds; II – Phosphates; III – Cu; IV – Cd; V - Mn; VI – Zn; VII – Cl; VIII – S; IX – Pb; X – Hg; XI – As; XII - oil products; XIII - pesticides

Table 12. The correlation matrix between main pollutant components of surface water, groundwater and wastewater in 2006

Issue	Groundwater												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Surface water													
I	0.958												
II		0.842											
III			0.917										
IV				0.851									
V					0.927								
VI						0.968							
VII							0.942						
VIII								0.959					
IX									0.963				
X										0.895			
XI											0.882		
XII												0.839	
XIII													0.884
Waste water													
I	0.732												
II		0.711											
III			0.699										
IV				0.811									
V					0.758								
VI						0.698							
VII							0.699						
VIII								0.759					
IX									0.775				
X										0.783			
XI											0.772		
XII												0.748	
XIII													0.757

I – Nitrogen compounds; II – Phosphates; III – Cu; IV – Cd; V - Mn; VI – Zn; VII – Cl; VIII – S; IX – Pb; X – Hg; XI – As; XII - oil products; XIII - pesticides

Table 13. The correlation matrix between main pollutant components of surface water, groundwater and wastewater in 2007

Issue	Groundwater												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Surface water													
I	0.972												
II		0.861											
III			0.902										
IV				0.931									
V					0.912								
VI						0.973							
VII							0.971						
VIII								0.986					
IX									0.942				
X										0.898			
XI											0.875		
XII												0.837	
XIII													0.898
Waste water													
I	0.729												
II		0.701											
III			0.712										
IV				0.721									
V					0.753								
VI						0.763							
VII							0.791						
VIII								0.73925					
IX									0.749				
X										0.769			
XI											0.734		
XII												0.758	
XIII													0.783

I – Nitrogen compounds; II – Phosphates; III – Cu; IV – Cd; V - Mn; VI – Zn; VII – Cl; VIII – S; IX – Pb; X – Hg; XI – As; XII - oil products; XIII - pesticides

Table 14. The correlation matrix between main pollutant components of surface water, groundwater and wastewater in 2008

Issue	Groundwater												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Surface water													
I	0.963												
II		0.861											
III			0.908										
IV				0.831									
V					0.947								
VI						0.985							
VII							0.955						
VIII								0.928					
IX									0.943				
X										0.896			
XI											0.875		
XII												0.901	
XIII													0.859
Waste water													
I	0.729												
II		0.697											
III			0.705										
IV				0.792									
V					0.773								
VI						0.714							
VII							0.751						
VIII								0.749					
IX									0.793				
X										0.759			
XI											0.739		
XII												0.749	
XIII													0.763

I – Nitrogen compounds; II – Phosphates; III – Cu; IV – Cd; V - Mn; VI – Zn; VII – Cl; VIII – S; IX – Pb; X – Hg; XI – As; XII - oil products; XIII - pesticides

Table 15. The correlation matrix between main pollutant components of surface water, groundwater and wastewater in 2009

The results of the multiregression analyze applied to water quality prediction in the future, show that only 0.07% of the original variability cannot be explained when dependent variable was represented by the nitrogen compounds, 0.05% when metals represented the dependent variable, 0.09% when phosphorus and/or phosphates were the dependent variable, and 0.11% when pesticides are dependent variable. This emphasizes the accuracy of this prediction model for explaining the approached water pollutants evolution.

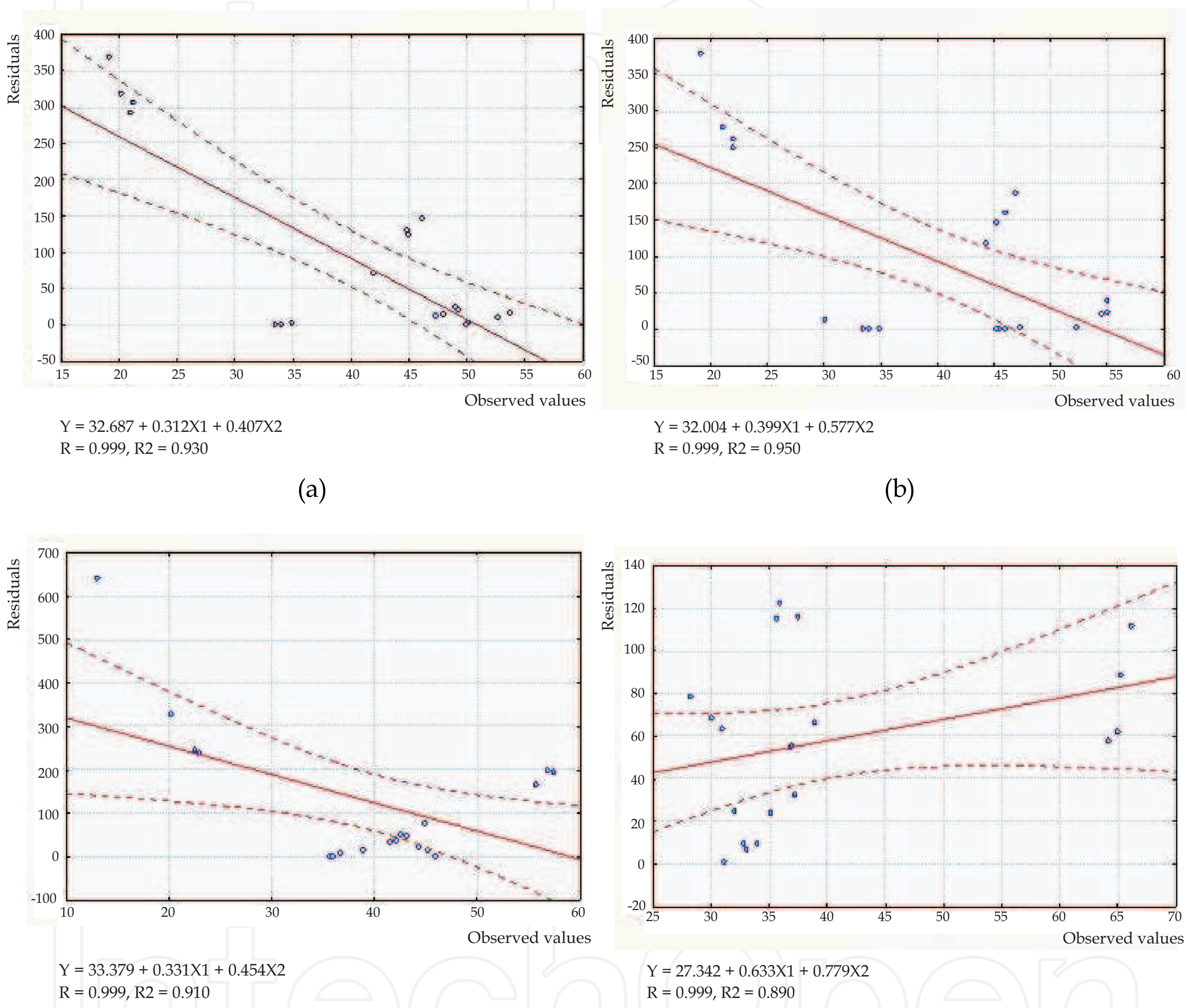

Fig. 9. Scatter diagram depicting the multiple correlation analysis between variables. (a) correlation between nitrogen compounds and Cl, S, Pb, Cd, Hg, As, oil products, pesticides, phosphates (or P); (b) correlation between Pb, Cd, Hg, As, and Cl, S, oil products, pesticides, nitrogen compounds, phosphates (or P); (c) correlation between phosphates (or P) and nitrogen compounds, Cl, S, Pb, Cd, Hg, As, oil products, pesticides; (d) correlation between pesticides nitrogen compounds, Cl, S, Pb, Cd, Hg, As, oil products, phosphates (or P)

9. Conclusion

The main water pollutants identified during the analyzed time interval and all water categories (surface water, groundwater and wastewater) were: nitrogen compounds, Fe, P, Fe, Mn, Cu, Cd, Zn, pesticides and detergents. The surface waters are mainly contamined with metals (Cu, Cd, Mn, Zn), and contamination ranges between 15 – 22% of analyzed water bodies. The groundwater pollution frames within 20 – 25% of total ground water and the main pollutants are: NO_2, NH_4, P, PO_4^{2-}, Cl, S, Pb, Cd, Hg, As, oil products, pesticides. 70.2 – 76.5% of total analyzed wastewater resulted from the main sources of pollution, have reached the natural receptors, especially rivers, not cleaned or insufficiently purified. Strong correlation (0.925) was identified between phosphates and nitrogen compounds in groundwaters. The same trait (strong correlation) can be attributed to the correlations between Cu, Cd, Mn, Zn (0.858 ÷ 0.921) in surface waters and NO_2, NH_4, Cl, S, Pb, Cd, Hg, As, oil products, pesticides (0.793 ÷ 0.921) in groundwater. Correlations were also calculated between main pollutants of: surface water and ground water, surface water and wastewater, ground water and wastewater. Their values (0.695 ÷ 0,986) emphasize the strong interdependence between pollutants matrices.

Major issues that should be addressed in future research include the ability to simulate regional water quality and its sensitivity to social and economical realities. Research needs to be undertaken on the role of environmental management, particularly in view of increase the potential for diminishing the wastewater content in harmful pollutants, and extension of cleaning process of these waters.

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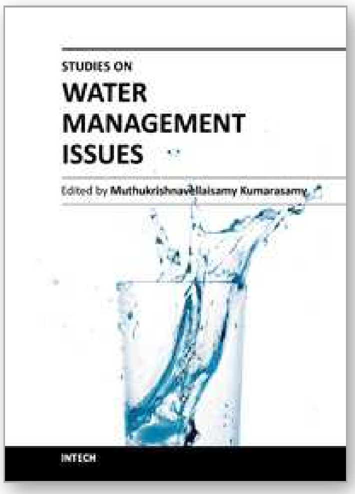

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