

# Study Regarding Dynamic of Groundwater Quality after Some Unusual Meteorological Phenomena

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*This paper presents the dynamic of quality parameters for groundwater in Borcea area, south - eastern of Romania, during period 2005 – 2010, after some unusual meteorological phenomena. This area is constantly flooded and the groundwater quality is changed because of physico-chemical and biological modifications, in consequence could not be used as drinking water. For this reason the physico-chemical and biological parameters of groundwater have been experimentally evaluated during this period. The results showed that the aquatic ecosystem has an incredible tendency to regenerate in time.*

*Keywords: unusual meteorological phenomena, groundwater parameters, ecosystem, Borcea area*

Borcea area is situated in south - eastern part of the Romania, on the left bank of the Borcea river which limited it [1]. This area is characterized by the fact that the groundwater network is located near the surface of the land. Due to this fact, the people made wells to use the groundwater so in the present there is a number of 40 wells for about 258 inhabitants. The depth of the wells varies between 3 and 40 meters [2]. But also this area is constantly flooded and the groundwater quality is frequently changed. Because of some meteorological phenomena, such as floods and heavy rain falls, the groundwater composition in Borcea area has suffered some physico-chemical and microbiological modifications in the period 2005 - 2010. These things might affect the quality of drinking water [3 - 6].

The aim of this paper was to study dynamic in time of the physico-chemical and biological groundwater parameters from Borcea area, before and after the unusual meteorological phenomena and to emphasize the evolution of drinking water quality.

## Experimental part

The groundwater samples have been collected as follows:

- the first moment was October 2005 after the heavy rainfalls which flooded and affected the groundwater quality in the Borcea area;
- the second moment was November 2007 after an unusual meteorological phenomena;
- the third moment is in fact the period between March 2008 and July 2010 when no important overflows are observed and is the period when the ecosystem is regenerated. For this period, the samples are taken twice a month;
- the fourth moment was July 2010 after the area was flooded.

The points of collected samples were wells from private households affected by the overflows. These points are:

- S1 - water samples collected from a 20 m deep well;
  - S2 - water samples collected from a 12 m deep well;
  - S3 - water samples collected from a 18 m deep well;
  - S4 - water samples collected from a 26 m deep well;
  - S5 - water samples collected from a 25 m deep well.
- The age of the wells are : S1 (25 years), S2 (29 years), S3 (30 years), S4 (50 years) and S5 (39 years).

A number of 15 samples have been collected from every point that means a number of 75 samples.

The gathering, transport and maintenance of the water samples for the bacteriological analyses were done according to Romanian standard legislation [7 – 10], [24 - 28]. For groundwater samples were used colorless bottles, with a take-out-top system right in the moment when the bottle reached the analyzed water or the study of subterranean fauna, were used only specific recommended methods [11 - 13].

The main physico - chemical parameters of water samples, using portable equipment and standard methods for water analysis, are:

- determination of pH (potentiometric method): WTW 82362 pH-meter;
- determination of total dissolved salts (potentiometric method): Consort C561 Multi-parameter;
- determination of free and total chloride (spectrophotometric method at a wavelength of 560 nm): Spectroquant kit (Merck);
- determination of anions (colorimetric method): phosphates - Aquaquant Kit 14445.0001, chlorides - Aquaquant Kit 14445.0001, nitrates - Aquamerck Kit 114408.0001, nitrites - Aquamerck Kit 111170.0001, sulphures - Aquaquant Kit 14416.0001, sulphates - Aquaquant Kit 14411.0001, and ammonia - Aquaquant Kit 14428.0001 (Merck);
- Determination of cations: spectrophotometric methods, portable spectrophotometer UV-Vis Spectroquant Merck;
- collection method applied is suggested by Negrea and collaborators: net/ nylon sieve with taper at the base of

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which it stands a plastic receiver, the net mouth is kept open by a hoop, above the opening is set a pack with bait (beef), net was introduced into the water with a rope until it enters the water mouth the bait without touching water sample was field setting with formaldehyde (final concentration 5%).

#### Determination of biological characteristics

The presence of some invertebrate species in the analyzed aquatic systems, for example rotifers species like *Trichocerca* ( especially *T. rattus*), *Synchaeta stylata*, *Asplanchnopus multiceps* genus, may indicate oligosaprobe waters. Also, the Actiniedida (Acarina) arthropodes: *Atractides gibberipalpis*, *Arrenurus (Truncaturus) fontinalis*, or copepode crustaceans (*Acanthodiptomus denticornis*) and amphipodes (*Niphargus*), may indicate oligosaprobe waters.

In this study, the species from the same genus may include  $\alpha$ - or  $\beta$ -mezosaprobies but also polysaprobies water species indicators (Table 2. b.).

We have been investigated these aquatic systems and evaluated the organisme communities using an biotic index (especially the Invertebrate Community Index).

In order to characterize surface water quality there is a series of biological indices, but to characterize the seepage water due to flood there are relatively few indices, most with a complex formula; the British Monitoring Working Party (BMWP) scoring system is divided by the number of invertebrate species, and or families; water quality can be described according to the BMWP score corelated with the nutrient levels (nitrates, ammonia and phosphates); another index - the Belgian Biotic Index, described by invertebrated fauna and ToxKit evaluation or - the Invertebrate Community Index, which use the detritivorus and predatory fauna ratio.

Biological parameters were analyzed using indicator species index and invertebrate comunity index [14 - 16].

The aquatic organisms characteristic to high quality well water are stenobiont and support limited variations of physical and chemical parameters, so their absence may be regarded as a quality indicator [17, 18].

As water quality becomes impaired, along with the disappearance of stenobiont species, some species that indicates beta or alpha- mezosaprobies water [19, 20, 23].

#### Results and discussions

The physico-chemical and biological parameters determined for groundwater samples in October 2005 are presented in Table 1 [21 - 27].

The physico-chemical and biological parameters determined for groundwater samples in November 2007 are presented in table 2 a. and 2 b.

The microbial load average (total coliforms) for all the samples is 2800 germs/100 mL in the year 2005 and 2640 germs/100 mL in the year 2007 (table 3), while fauna includes groups of invertebrate of inferior crustaceans and inferior insects, occasionally arachnids.

The total coliforms present in the collected water samples from S1, S2, S3, S4, S5 wells in October 2005 shown a high bacterial pollution degree (water could not be used for drinking or for domestic use). In the water samples from older S4 and S5 wells, the total coliforms (number of germs/100 mL) were lower by 0.9 and 1.08% compared with the water samples from recently S1 and S2 wells.

In the year 2007, the well S4 recorded the highest pollution degree, 3000 g of total coliforms. In March-July 2010, in the S4, S5 wells the lowest pollution degree between the five analyzed wells (200 g of total coliforms /

**Table 1**  
EXPERIMENTAL DATA FOR GROUNDWATER SAMPLES (OCTOBER 2005)

Parameter	S 1	S2	S3	S4	S5
Temperature, °C	11	13	10	11	10
pH (units of pH)	7.4	7.48	6.85	7.36	7.42
Ammonia (mg/L)	< DL	< DL	< DL	< DL	< DL
Total chlorides (mg/L)	300	200	150	300	200
Phosphates (mg/L)	1	< DL	< DL	< DL	< DL
Nitrates (mg/L)	10	10	15	10	15
Nitrites (mg/L)	0.05	0.05	0.05	0.05	0.05
Sulphates (mg/L)	300	300	140	300	200
Sulphures (mg/L)	< DL	< DL	< DL	< DL	< DL
Fixed residue (mg/L)	1415	3056	952	1305	1021
Hardness (°d)	21	21	21	21	21
Aluminum (mg/L)	< DL	< DL	< DL	< DL	< DL
Calcium (mg/L)	26	26	40	26	26
Copper (mg/L)	< DL	< DL	< DL	< DL	< DL
Iron (mg/L)	0.01	< DL	< DL	< DL	< DL
Magnesium (mg/L)	100	100	50	100	50
Potassium (mg/L)	< DL	< DL	< DL	< DL	< DL
Lead (mg/L)	< DL	< DL	< DL	< DL	< DL
Total Dissolved Salts (mg/L)	2140	3211	1012	954	1123
Zinc (mg/L)	< DL	< DL	< DL	< DL	< DL
Faunal groups*	Inferior crustaceans and insecta	Inferior crustaceans arachnida and insecta	Inferior crustaceans and insecta	Inferior crustaceans and insecta	Inferior crustaceans and insecta
Total Coliforms (no. germs/100 mL)	3300	2500	3000	2700	2500

\* Includes typical aquatic fauna but also some terrestrial forms accidentally wind-driven  
DL = Detection limit

Parameter	S 1	S2	S3	S4	S5
Temperature, °C	12	13	11	10	10
pH (units of pH)	7.52	7.62	7.12	7.25	7.50
Ammonia (mg/L)	< DL	< DL	< DL	< DL	< DL
Total chlorides (mg/L)	300	300	200	300	300
Phosphates (mg/L)	1	< DL	< DL	< DL	1
Nitrates (mg/L)	10	10	10	10	10
Nitrites (mg/L)	0.05	0.01	0.05	0.05	0.05
Sulphates (mg/L)	300	300	200	200	300
Sulphures (mg/L)	< DL	< DL	< DL	< DL	< DL
Fixed residue (mg/L)	1522	2855	1213	1041	953
Hardness (°d)	21	21	21	21	21
Aluminum (mg/L)	< DL	< DL	< DL	< DL	< DL
Calcium (mg/L)	32	32	50	26	20
Copper (mg/L)	< DL	< DL	< DL	< DL	< DL
Iron (mg/L)	< DL	< DL	< DL	< DL	< DL
Magnesium (mg/L)	50	100	100	50	50
Potassium (mg/L)	< DL	< DL	< DL	< DL	< DL
Lead (mg/L)	< DL	< DL	< DL	< DL	< DL
Total Dissolved Salts (mg/L)	2210	2850	1233	1018	1025
Zinc (mg/L)	< DL	< DL	< DL	< DL	< DL
Faunal groups*	Inferior crustaceans and insecta	Inferior crustaceans and insecta	Inferior crustaceans and insecta	Inferior crustaceans arachnida and insecta	Inferior crustaceans and insecta
Total Coliforms (no. germs /100 mL)	2500	2500	2700	3000	2500

\* Includes typical aquatic fauna but also some terrestrial forms accidentally wind-driven  
DL = detection limit

**Table 2a**  
EXPERIMENTAL DATA FOR  
GROUNDWATER SAMPLES  
(NOVEMBER 2007)

Phylum	Taxa	Environmental Life
<b>Rotatoria</b>	<i>Eosphora</i> sp.	Fresh until brankish water; mezosaprob species
	<i>Rotaria</i> sp.	Fresh water; eurioic and mezosaprob species;
	<i>Philodina</i> sp.	Fresh until brankish water; eurioic and mezosaprob species;
	<i>Brachionus</i> sp.	Aquatic habitats with high level of organic material, mezosaprob species;
<b>Nematoda</b>	Varia	Aquatic
<b>Arthropoda</b>		
Genus <b>Arachnide</b>	<i>Phreatohydracarus</i> sp.	Aquatic
Genus <b>Chelicerata</b>	<i>Hydracarina</i> sp.	
Genus <b>Araneae</b>	<i>Torrenticola</i> sp.	Freatobiu species
	<i>Caspihalacarus</i>	
Genus <b>Crustacea</b>	<i>Acanthocyclops</i> sp.	Aquatic and euribiotic species
	<i>Eucyclops</i> sp.	
	<i>Diacyclops</i> sp.	

**Table 2b**  
TAXA LIST WITH HABITAT  
CHARACTERISTICS

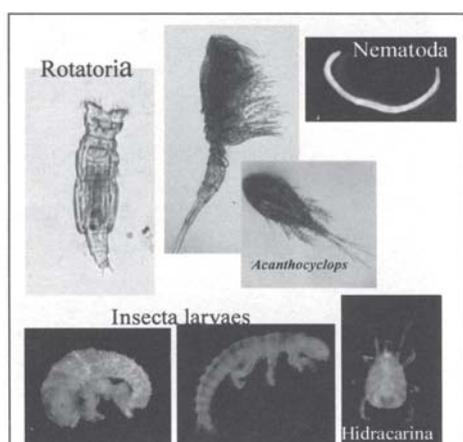


Fig. 1. Some species which are identified in the water samples

100 mL) was registered. After the flood, in July 2010, in the oldest wells, the highest pollution degree was recorded.

The term "total coliforms" as used in coliforms group usually refers to a particular group of bacteria belonging to the family Enterobacteriaceae (the genera *Escherichia*, *Citrobacter*, *Enterobacter* and *Klebsiella*). The microbial

charge from collected water samples represents a contamination indicator and this water source is prohibited for drinking and domestic use according to current norms [24, 25]. The performed analyzes indicates higher values for total chlorides, phosphates, fixed residue, sulphates and hardness. The concentration for aluminium, copper, iron, lead and zinc ions are maintained in standard values. The groundwater microbiological analyses confirm the presence of faecal coliforms.

The presented results indicated that these water sources are prohibited for domestic use.

For the period March 2008 – July 2010 the same quality parameters have been detected. The average values of physico-chemical and biological parameters determined for groundwater samples in March 2008 – July 2010 are presented in table 4.

The lowest average values of microbial load and the abundance of invertebrate fauna which have been recorded in the period of the years 2008 - 2010, could be explained by a relatively prolonged period of drought.

The experimental data demonstrate that the values for all the parameters are in the standard limits. This means that in time, the entire aquatic ecosystem was regenerated and the water quality has been improved.

Parameters	S1	S2	S3	S4	S5
Total coliforms (no.germs/100 mL)/October 2005	3300	2500	3000	2700	2500
Total coliforms (no.germs/100 mL)/November 2007	2500	2500	2700	3000	2500
Total coliforms (no.germs/100 mL)/ March 2008 - July 2010	300	400	500	200	200
Total coliforms (no.germs/100 mL)/ July 2010	4100	5000	5500	4800	4500

**Table 3**  
MICROBIAL CHARGE OF THE  
GROUNDWATER SAMPLES IN THE  
PERIOD OF OCTOBER 2005 – JULY  
2010

Parameter	S 1	S2	S3	S4	S5
Temperature (°C)	12.5	11	10	11.8	10
pH (units of pH)	7.25	7.60	7.53	7.49	7.22
Ammonia (mg/L)	0.025	< DL	< DL	< DL	< DL
Total chlorides (mg/L)	150	150	150	150	150
Phosphates (mg/L)	< DL				
Nitrates (mg/L)	0.5	10	10	0.5	0.5
Nitrites (mg/L)	< DL				
Sulphates (mg/L)	150	200	150	150	150
Sulphures (mg/L)	< DL				
Fixed residue (mg/L)	233	451	114	394	318
Hardness (°d)	20	20	20	20	20
Aluminum (mg/L)	< DL	< DL	0.1	0.1	< DL
Calcium (mg/L)	18	25	18	35	18
Copper (mg/L)	< DL				
Iron (mg/L)	0.04	< DL	< DL	0.02	< DL
Magnesium (mg/L)	30	30	20	30	20
Potassium (mg/L)	< DL				
Lead (mg/L)	< DL				
Total Dissolved Salts (mg/L)	750	648	617	458	662
Zinc (mg/L)	< DL				
Faunal taxa	Insecta	Insecta	Insecta	Insecta	Insecta
Total Coliforms (no. germs /100 mL)	300	400	500	200	200

**Table 4**  
EXPERIMENTAL DATA FOR  
GROUNDWATER SAMPLES  
(MARCH 2008 – JULY 2010)

Parameter	S 1	S2	S3	S4	S5
Temperature, °C	13	13	20	13.5	14
pH (units of pH)	7.84	7.77	7.63	7.43	7.07
Ammonia (mg/L)	< DL	< DL	< DL	< DL	0.025
Total chlorides (mg/L)	300	300	75	150	150
Phosphates (mg/L)	0.34	0.092	0.046	0.095	< DL
Nitrates (mg/L)	25	10	10	25	25
Nitrites (mg/L)	0.1	0.05	0.05	0.1	0.1
Sulphates (mg/L)	300	300	300	200	300
Sulphures (mg/L)	< DL	< DL	< DL	< DL	< DL
Fixed residue (mg/L)	3440	1360	1240	1400	1360
Hardness (°d)	21	21	21	21	21
Aluminum (mg/L)	10	10	10	10	10
Calcium (mg/L)	6	9	12	9	9
Copper (mg/L)	< DL	< DL	< DL	< DL	< DL
Iron (mg/L)	0.02	< DL	0.02	< DL	< DL
Magnesium (mg/L)	500	300	< DL	100	< DL
Potassium (mg/L)	250	< DL	< DL	< DL	< DL
Lead (mg/L)	< DL	< DL	< DL	< DL	< DL
Total Dissolved Salts (mg/L)	2960	2170	582	1040	1460
Zinc (mg/L)	< DL	0.1	0.4	< DL	< DL
Faunal taxa*	Inferior crustacea	Inferior crustacea and insecta	Insecta	Inferior Crustacea, Myriapoda	Insecta
Total Coliforms (no. germs /100 mL)	4100	5000	5500	4800	4500

**Table 5**  
EXPERIMENTAL DATA FOR  
GROUNDWATER SAMPLES  
(JULY 2010)

\* Includes typical aquatic fauna but also some terrestrial forms accidentally wind-driven  
DL = detection limit

The physico-chemical and biological parameters determined for groundwater samples at the beginning of July 2010, after unusual meteorological phenomena when the surface area was flooded, are presented in table 5 and figure 2.

The high value both in terms of microbial load, 4780 germs/100 mL and in terms of abundance of invertebrate fauna has been recorded in the year 2010; this year was characterized by a long period of floods.

Finalizing the study of the above mentioned aquatic systems we underlined that in the samples have been individualized two categories of invertebrate organisms: exclusive terrestrial invertebrate (from traps, accidentally, wind transported and other causes) and aquatic invertebrates (multiple entrance ways). This aspect could be explained in that way that the invertebrate fauna caught some terrestrial species of arachnids, myriapods, isopode (peracaride crustaceans) and insects, due to excessive moisture and water levels.

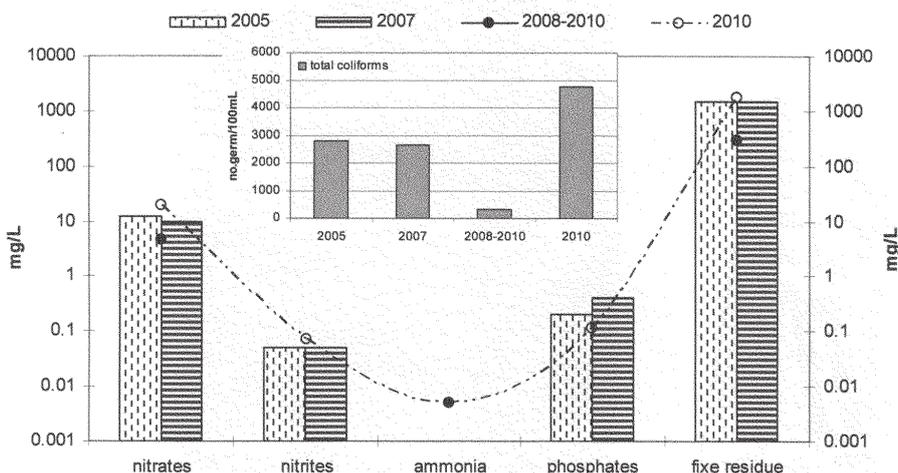


Fig. 2. The nutrients content and coliforms charge variation of groundwater from Borcea area, for the period 2005-2010

In our study we focused also on the aquatic fauna and based on the identified species we characterized the organisms communities from the analyzed aquatic systems; in the 10 samples from the months October and November (year 2005 and 2007, when there are registered episodes of unusual meteorological phenomena), we have been recorded 10 specific and ultra specific taxa from crustaceans group; the presence of copepods and rotifers as dominant species and majority cited in the literature is characteristic for the  $\beta$ -mezosaprobe waters (table 2.a.); the presence of insects larvae we consider that is representative for the utilization of some habitats which offers optimum conditions for the trimmer species.

The results indicate that the values of pH and temperature are in standard values. Higher values were recorded for phosphates, nitrates, nitrites, sulphates and fixed residue. Also, aluminium and magnesium ions concentrations are higher than admissible values for drinking water. The groundwater microbiological analyzes confirm the presence of faecal coliforms (fig.2).

## Conclusions

The dynamic in time for the main parameters of groundwater quality is as follows:

- the evolution in time of chlorides content shows that the higher values are registered after all the natural overflows, excepting the samples from S3 well;
- for the phosphates content, there is an important exceeding of normal values especially after the unusual meteorological phenomena from 2005 and 2007. After the flooding from 2010, this parameter recorded low values;
- as pollution indicators, the nitrites and nitrates ions content in water samples, after the unusual meteorological phenomena from 2010, presents higher values than the ones for the year 2005 or 2007. In the period 2008 – 2010, the nitrites ions content in the water samples presented low values, under detection limit;
- the sulphates content recorded high values in the period of overflows. The samples from S3 well have a low concentration of sulphates during the disaster but registered high values in 2010;
- the fixed residue recorded higher values in the periods of overflow and low value in the period of 2008 – 2010;
- from the microbiological point of view we concluded that the wells analyzed have indicated a very high degree of bacterial pollution;
- identified fauna belong to six supraindividual taxonomic groups, of which, only two species include groundwater environmental; most of the fauna is characteristic mezosaprobe water, given the temporary

nature of flood events (even if sometimes for periods of time quite long) and because the periods of monitoring drinking water sources were episodic, it was not possible to obtain an index of biotic upon which to classify these sources of water; in addition, because in the studied aquatic systems, the number of the invertebrates taxa was very low (as number of species and also as abundance), it is very difficult in this case to use an Invertebrate Community Index;

- further studies carried out for longer periods without interruption, allow us to verify the classification using biotic index sources of groundwater and surface water as drinking water sources.

After the three unusual meteorological phenomena present in Borcea area, have been observed the variation of specific groundwater parameters which indicate that the water quality is improved. The results obtained demonstrate that the studied aquatic ecosystem present an important capacity of regeneration in time.

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