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Full Length Research Paper

Environmental monitoring of town Kyustendil, Bulgaria

Anton Sotirov

Bulgarian Academy of Sciences, Institute of Mineralogy and Crystallography "Acad. Ivan Kostov, Sofia, Bulgaria
Tel.: ++359-899773926, Fax: ++359-29797056, E-mail: sotirov_anto@hotmail.com

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Present investigation gives information about some parameters of the environment of town Kyustendil, Bulgaria. The parameters were chosen on the basis of the main purpose of the study – collecting of information about the condition of water resources, precipitations, soils, radiation background, and air around the town and making decisions and conclusions. Measurements of the rainfall, soil, water, and radiation were implemented every day during 2 years period and seasonal measurements of the water of Banshtitsa River, which crosses the town, were done.Method of measurement "in-situ" was chosen on the terrain through direct sampling "grab samples", because the advantage of the method is high authenticity, correctness and accuracy of the investigations. Using of digital instruments was preferred, because their possibilities for quick, comfortable and precise measurements of the studied parameters.There is not reference or public data for scientific or practical environmental studies of the region. Published data for environmental monitoring of urban area of town Kyustendil, Bulgaria is published only by the author.

Key words: environmental monitoring, soil, air, radiation, water, Bulgaria

INTRODUCTION

Town of Kyustendil is situated in West Bulgaria near to the Osogovo Mountain (Figure. 1). It is located in the central part of the Balkan Peninsula. The altitude of the studied area is 512 m. The climate of the town is transitional continental to Mediterranean. The precipitations are not very intensive as their annual amount are about 589 mm. They have almost equal distribution by seasons. It is snowing usually from November to March as the average snow thickness is 30 cm with duration about 15 days. In spite of this, there are many water sources at the region around the town - rivers, springs, lakes, mineral, and underground water (Ivanchev, 1996).

River of Banshtitsa springs from Osogovo Mountain, located in Central Part of Balkan Peninsula and flows in Struma River as crosses longitudinal the town of Kyustendil. It flows from South-West to North-East direction. The length of the river is 11 km (Ivanchev, 1996). In the frame of the town Kyustendil, the river bed is corrected as traces out nearly straight line. The river bed is covered artificially with stone fragments with different nature – syenite, granite, gneiss, flint, and shale. There is an interval of the river, which is covered with concrete (culverted interval) with length 300 m. Environmental monitoring of the river of Banshtitsa has not been done till now. Government and Municipal institutions do not have any data about water parameters. There is not reference or public data for scientific or practical studies. Investigations were done only for regions near to the river in the mining area of Osogovo Mountain (Dimitrov et al., 2004).

Published data for environmental monitoring of urban area of town Kyustendil, Bulgaria is published only by the author (Sotirov et al., 2013, 2008) and (Pistalov, Sotirov, 2010).

Theoretical part

Environmental monitoring is the process of observation and control of the condition of the environment for all components (air, water, soil, rocks, eco-systems, and biological species) and warning for critical situations, damages or dangerous for the environment or people. It

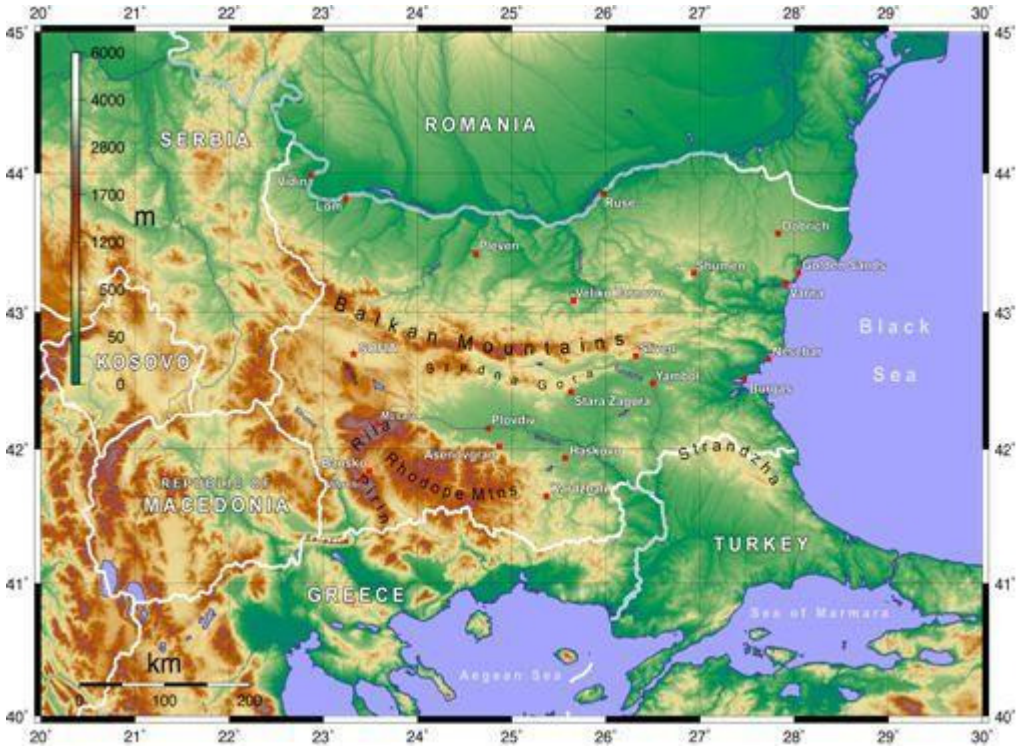

Figure 1: Location of the studied area

is established a network of stations (points) for collection of data for the condition of the environment on the territory of the whole country. The places of the stations are determined on scientific basis. Usually the stations are located around contamination sources. It is a rule that the sampling should be done for all components of the environment – air, surface and underground water, soil, rocks, and etc. The monitoring usually gives us a picture about the moment condition of the studied system or object, but when compare with data from previous monitoring, we can receive reliable information about the future tendencies of the observed system. Good organized monitoring ensures the important package of data, which is necessary for statistical modeling of the studied object or system (Simeonova, Lovchinov, 2008).

METHODS

The Methods are chosen according to the Bulgarian National System for Environmental Monitoring, which keeps informational data base on national and regional level. The National System for Environmental Monitoring implements permanent observations in many static and mobile stations.

The present investigation gives information about some parameters of the environment in the town of Kyustendil, Bulgaria. The parameters are chosen on the basis of the main aim of the study – collecting of information data for the condition of water resources, precipitations (rain, snow, hail), soils and air in the town and making of decisions and conclusions.

Measurements of the rainfall were implemented during 1 year and seasonal (winter and summer) measurements were done of the river of Banshtitsa, which crosses the town.

Collection of the rain and snow was done in sterile graduated measured glass on 2 m high stand base in one point in the town.

Present investigation includes measurements of the physical parameters of the water of river of Banshtitsa in the urban part of town of Kyustendil. Samples are taken and measurements are done by intervals of 250 m along the river and by this way environmental monitoring of 3 km interval is done.

The measurement is executed with instrument „Hanna" HI9813-6. It is measured acidity of the water (pH), temperature of the water (t,℃), conductivity (EC, µS), total dissolved sulfur (TDS, ppm), as preliminary calibration of the instrument was done with calibration solutions.

Another instrument used for study of the water is spectral photometer (tintometer) "Lovibond". With this instrument are established: free, total and combined chlorine Cl, acidity pH, cyanuric acid CYS, total alkalinity $CaCO_3$, free, total and combined copper Cu, and iron Fe. Nitrate and Nitrite content in the water and soils are established through indicator test paper with range 0-10-25-50-100-250-500 mg/l. Acidity of the soil is established with pH indicator test paper with range pH=1-14.

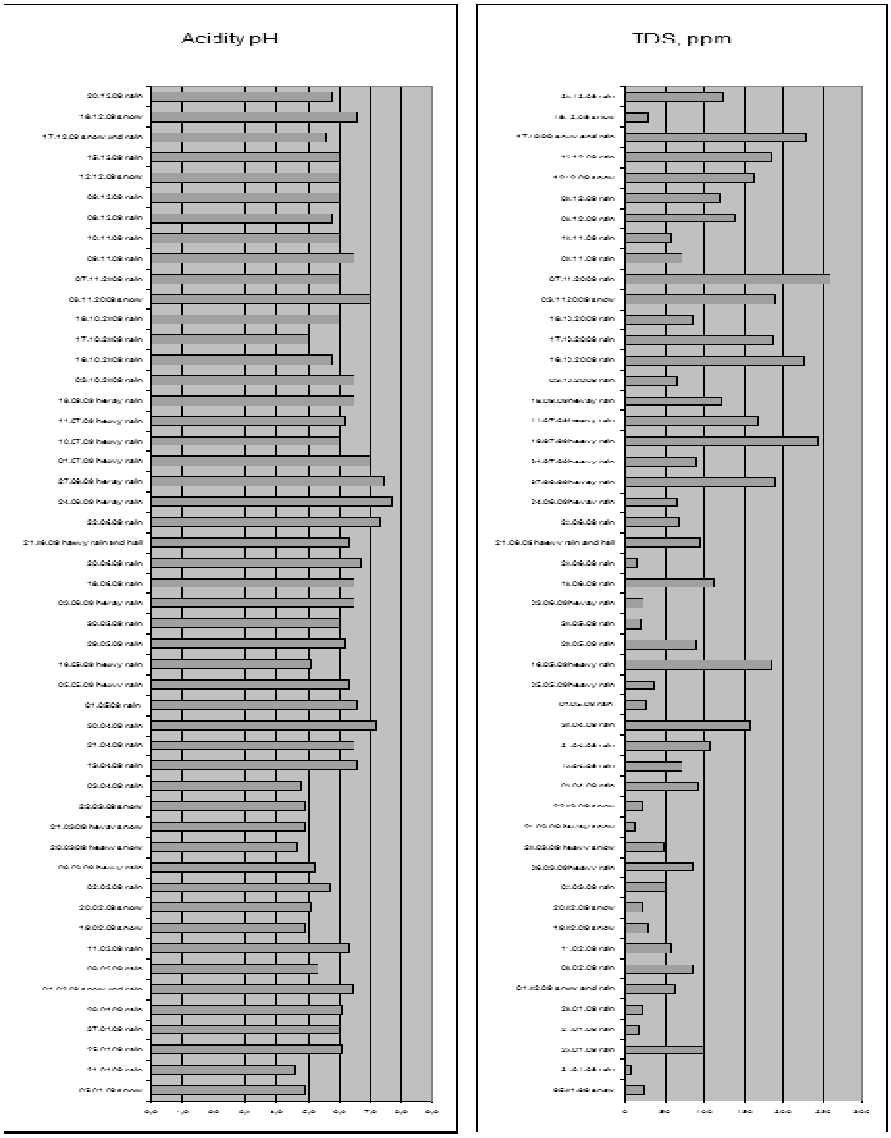

Figure 2: Graphics of the distribution of rain parameters by dates

Radiation of the air and water was measured also with apparatus “Radex” RD1503. The monitoring equipment is purchased with the help of Operative Program “Human Resources Development” of the Structural Funds of EU.

Air parameters are measured with instrument “Dräger” X-AM7000 for CH_4, CO, H_2, and O_2. The content of CH_4 and CO_2 is measured also with interferometer “SHI-11”. Concentration of the SO_2 in the air is measured by instrument “Crowcon Gasman”. Microscopic studies were done with stereo microscope “CETI” (STAR-24ED) with magnification x40 with reflected and transmitted light with digital video-camera “Globecam” D and computer program “Image Driving Software” DCE-2.

Method of measurement “in-situ” was chosen, on the terrain through direct sampling “grab samples”, because the advantage of the method is high authenticity, correctness and accuracy of the investigations. Using of digital instruments is preferred, because their possibilities for quick, comfortable and precise measurements of the studied parameters.

RESULTS AND DISCUSSION

Results from the measurement of the parameters of the precipitations

During the 12-months studied period, 50 days had enough rain (snow) intensity for implementation of measurements. Precipitations with pH<5 were determined as acid (Figure. 2). There were also 7 days with pH about and little bit more than 5,0 which we

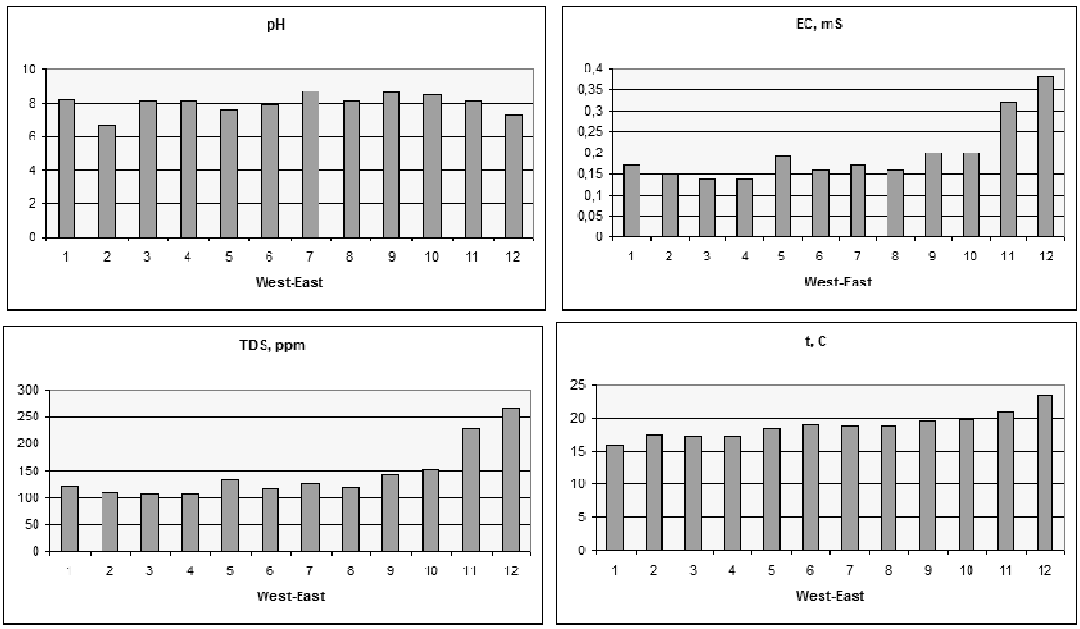

Figure 3: Measured summer parameters of the water of Banshtitsa river

determined as low acid. Probably the reason for high acidity of the rain and snow is using of coal for domestic heating during the winter. The coal is traditional source of heating in our town, because there are many coal deposits around. Municipality Kyustendil has 26 000 households and only about 6000 are gasified, according to the Municipality. The households use about 1,5 tones coal per winter, according to this investigation through the method of interview. Most families use coal with high content of ash ~30 ppm and sulfur – about 7 ppm from the nearest coal deposits Pernik, Bobov dol and Katrishte. By that way about 2000 t SO_2 is thrown away in the narrow Kyustendil cattle. Possible source of contamination might be also the nearest asphalt plants. The third possible source of contamination of the atmosphere with SO_2 is the fact that the town is in the 30^{th}-kilometers zone of the electric plant Bobov dol.

There is not established relation between the acidity of the precipitations and the temperature of the air during the winter. But there is a relation between the temperature of the air and the Total Dissolved Sulfur (TDS). When the temperature goes high, the TDS content also increases. Because of this reason probably the acidity of the rain in town of Kyustendil comes mainly from sulfur acid formed in the atmosphere. Other measured parameter is the conductivity of the rain and snow, which is an indicator for presence of admixture in the water. Its amount is not very high, but it was established presence of micro-elements, which is probably a result of dust and ash into the air, result of the burning of coal and transportation. It was not established relation between the temperature of the air and rain with the other measured parameters (Figure. 3).

Results from the measurements of the water of Banshtitsa River

Summer monitoring 2009

During summer monitoring it was measured different values of the acidity of the water than the winter measurement. At whole the water during summer has higher alkalinity, probably because of high concentration of washing chemicals coming from the canals which flow into the river and using of fertilizers in the gardens and farms on the both sides of the river. The acidity at that time varied between pH=7,3 (one point only, again the acidity was higher in the housing complex “East”) and pH=8,7 (immediately after culverted interval).

Electrical conductivity (EC) and Total dissolved sulfur (TDS) were almost the same as the winter measurements or it means that the salt and mineral content and sulfur have almost permanent source during the seasons. Amount of Total dissolved sulfur during the summer is highest in the eastern part of the town, where the coal ashes form big embankments. At the beginning of the town, the sulfur content in the water is not very high, because the illegal landfill had been cleaned by the Municipality as a result of our publication. During the summer measurement it was established again temperature anomaly of the water under the culverted interval – almost -1.5◦C (Figure. 3).

High radiation of the water was detected in the beginning of the town, exactly at the place of the former illegal landfill and of the water under the culverted part of the river (0,32-0,36 μSv/h). Other place with higher radiation of the water is the place of dumping of coal ash

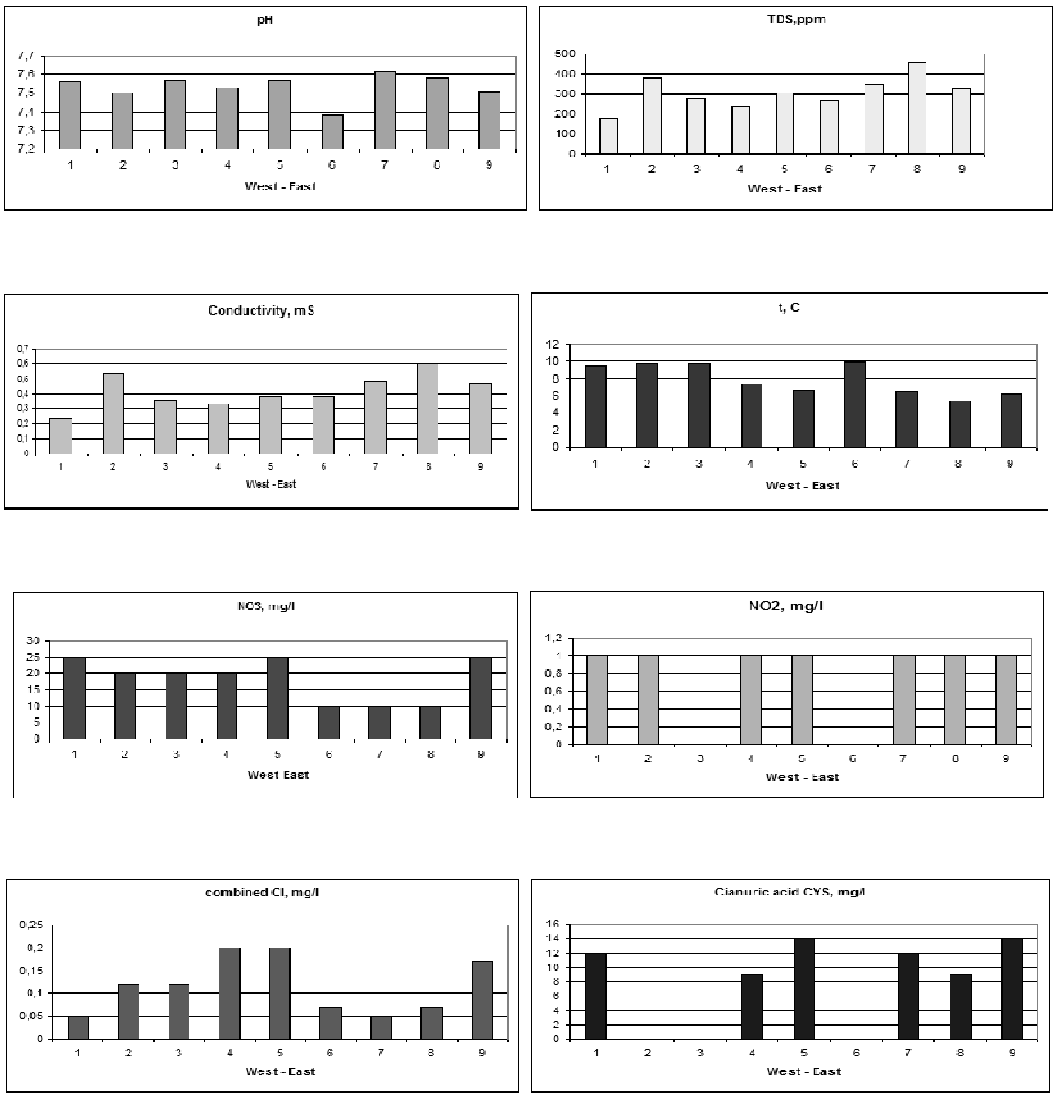

Figure 4: Measured parameters of the water of river of Banshtitsa during winter period

in the housing complex “East” (0,24 µSv/h).The cluster analysis of the summer measurements shows high relation between EC, TDS and temperature of the water. Probably solubility of the sulfur and salted minerals become better with the increasing of the temperature (Figure 5).

There were established problems with the culverted part of the river. Cracks and leaks of polluted water on the concrete will make problems in the future. One of the canals coming from the SPA Centre of the town had very high acidity pH~4. Probable reason for this acidity is using of chemicals from the business.

Winter monitoring of the water of Banshtitsa river

The acidity of the water is normal about pH=7,5. The mineral content has decreased as well as the total dissolved sulfur. The nitrite and nitrate contents are normal for surface water, according to the Nitrate Directive of EU ~10-25 mg/l. Total alkalinity $CaCO_3$, chlorine Cl, copper Cu, and iron Fe are also in the frame of normal. Presence of cyanuric acid CYS was measured, which is a part of the disinfectants, bleaching solution, pesticides and other chemicals with utilization from the industry. In the nature cyanuric acid exists in contaminated water and in waste streams from plants producing cyanuric acid (Figure. 4).

During winter measurements was established contamination of the canals which flow in the river. It was measured high concentrations of all parameters in the water of the canals, including TDS, total alkalinity, and cyanuric acid. There is relation between the places of sampling and their content. For example, the place of former illegal landfill is rich of nitrate NO3-, Cu, and Fe. The culverted part of the river is characterized with high

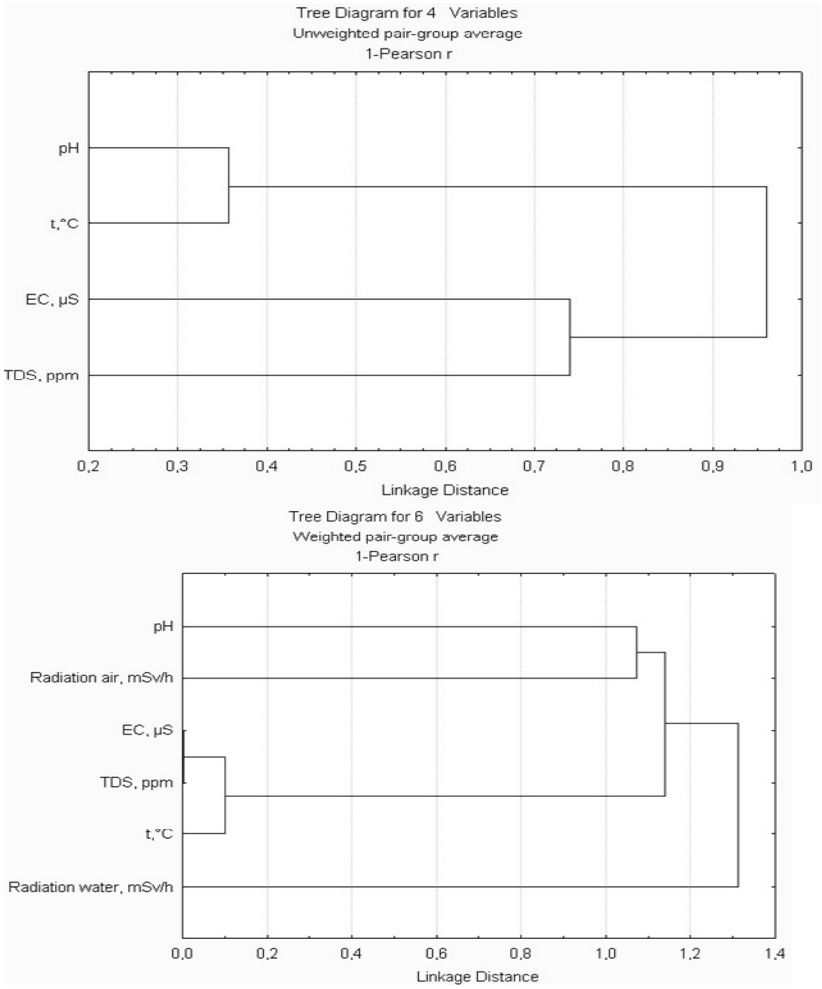

Figure 5: Cluster Analysis – summer measurement (Border level 0,43)

content of nitrate NO3-, Chlorine Cl and Cyanuric acid. The point after culverted part of the river had high radiation level again.

Water from 5 m-depth in a drill near the river was measured also. The water has high total alkalinity and it is contaminated with sulfur 1742 ppm and nitrate 250 mg/l. The water is not suitable for drinking.

Results from the measurements of the soil parameters in the town

The acidity of the soils in the town of Kyustendil is normal pH=5,5-7,5. Some points show high acidity, probably as a result of human activity. It is seen from the location of the samples. For example the soil around the shopping centre, car-wash near the river, the garden near to the shoe plant have acidity pH=5,5. The soil at the gas station and park has very high acidity pH=4,0 and high radiation. The sediment of the river of Banshtitsa has highest alkalinity.

High concentrations of Nitrate NO_3^- and Nitrite NO_2- are established in the soil at gas station “Shell”, Forest park “Hisarlaka” and Hotel “Velbujd” which are almost at the critical level according to the Nitrate Directive of European Union (91/676/EEC). The soils in the central parts of the town has nitrate 3 times more than the limit permissible values. It is probably a result of excessively using of artificial fertilizers from the municipal employees.

Results from the measurement of the gas content in the atmosphere of the town

The air of town of Kyustendil is characterized with high dust content. The most contaminated places are the crossroad at the city swimming pool and the crossroad at the Iron Bridge, where the concentration of the hydrogen is 20 ppm and carbon oxide 10 ppm. The highest radiation was measured at the crossroad at the east part of the town 0.28 µSv/h. Very low contamination is established around west part of the town.

Results from the measurement of the common radiation background in town of Kyustendil

The normal radiation background of the town is 0,16-0,20 µSv/h, according to data taken from Civil Protection Department of Bulgaria. According to the National Automated System for permanent control of the radiation gamma background in Bulgaria (RaMo), established in 1997, the normal radiation background in Bulgaria varies between 0,06 and 0,60 µSv/h. For the 12-months period, we have established that during 2009 almost half of the days, the radiation background was normal and the other half days of the year were with higher radiation background as sometimes went to the alarm level 0,32-0,36 µSv/h or higher.

As whole the radiation situation in the town is normal and there were not observed big anomalies, which might be connected with the human activity. The mountain area near the town usually has radiation about 0,60 µSv/h, because it is built by Plutonic syenite. We observed that the months of the year with more stable atmospheric situation have more days with normal radiation background – February, April, May, July, August, and September. But the months with snow and thunderstorms as January, March and June has high level of radiation background. Increasing of the intensity of the sources of ionization radiation in the atmosphere during these months is a result of meteorological phenomenon.

It was observed that in case of earthquake, the radiation background goes high on the same date or 1-2 days before it, depending from the distance to the epicenter.

There is not established relation between the temperature of the air, power of the Sunny activity, part of the day and common radiation background.

CONCLUSIONS AND DECISIONS

Conclusion and decision for the acidity of the precipitations in Kyustendil

The coal has been using for domestic heating in the region very intensive since 1990. Until 1990 most of the households had used mazut and naphtha. After 1990 the coal have used mainly because of the cheap price. During last 10 years part of the households were gasified. A decision for decreasing of the pollution of the air and acidity of the rains is gasification of the town. Other way for protection of the urban environment is using of renewable energy sources – solar, wind and geothermal. The high acidity of the precipitations during the winter and spring caused poor and sick agricultural crops. It is important to be solved the problem with the domestic heating for decreasing of greenhouse gases in the atmosphere of the town, which cause high acidity of the rainfalls. The soils of the Kyustendil cattle are naturally acid with pH=5,5-6,5 and the acid rains might break delicate border of pH=5,0.

Decisions and conclusions about environmental problems of Banshtitsa River

One of the most important decisions is society and institutions to be informed about the established ecological problem. As a result of implemented study we suggest following decisions:

- Purifying plant must be built at the place where the river entries in the town with a view to improving of the ecology of urban environment.
- Observed household and business canals should be led to the central sewerage.
- The river bed must be cleaned from the dumped waste.
- At the exit of the river from the town, the river bed must be cleaned from the dumped coal ash and measures should be taken for solving of the problem with household waste water and illegal landfills.
- Municipality of Kyustendil should present for the inhabitants special non-combustible containers for collection of the coal ash and its deposition in special landfills.
- Strategy for decreasing of using of fossil fuels (coal) for domestic heating should be elaborated by the Municipality.
- Investigation should be implemented in detail for establishment of the reasons for high radiation of the water and figure out if it is a natural process or a result of human activity and taking of measures. After cleaning of the landfill, the radiation values were not changed and they are still higher than the natural radioactive background.
- Finally, the Municipality of the town must change its decision to culvert the river for building of parking places and shopping centers.

Decisions and conclusions about soil contamination

Vegetable gardens along the river have normal concentrations of nitrate, nitrite and normal acidity. It means that the people of the town do not use a lot of artificial fertilizers and chemicals, but the gardens and parks which are property of the Municipality have high concentration of nitrate. We expected opposite results. Business places also are contaminant of the soils for example gas stations, hopping places, car-washes, plants, and other. Soils at these places are characterized with high acidity and concentrations of nitrate and nitrite. The Municipality administration should take measures for these contaminations.

Decisions and conclusions about the contamination of the air in the town

Main characteristic of the air is the high level of dust content. The measurements show that several crossroads of the town are contaminated with some gases, which are results of the transportation. Two crossroads had high concentrations of hydrogen 20 ppm and carbon dioxide 10 ppm. All other crossroads have lower gas contamination.

Decisions and conclusions about common radiation background

As a result of the executed measurements we can say that the radiation background in the town is normal. It varies between normal values 0,16-0,20 µSv/h. Only in separate days it reaches the alarm level of 0,36 µSv/h or little bit more, but probably that it is a result of high level of natural ionizing radiation, provoked by natural phenomenon – meteorological or geological as snowing, thunderstorms, earthquakes. Another reason might be the influence of the Plutonic syenite which is closely to the town.

Radiation of the rain and snow in the studied period is also normal, but in case of thunderstorms, heavy rain and snow, the radiation of the water increases and usually reaches the alarm level 0,36 µSv/h or over alarm level 0,44 µSv/h in cases of hail.

The radiation of the surface water of river of Banshtitsa is high as we are not able to determine exactly the reason for it. Probably it is a natural process, because of the fact that the river springs and flows through the Osogovo Plutonic syenite. But on the other hand the points with highest radiation are at the places with high contamination of the water – the illegal landfill, culverted interval, and the canal. Also in the east part of the town, where people dump coal ash, the radiation of the water was again very high. We measured radiation 0,36 µSv/h at all above mentioned points in spite of the low radiation of the air at these places.

Studied spring, mineral and drinking water in the town have normal radiation values 0,20 µSv/h. Radiation of the soils is normal also with an exception of one point, where we measured 0,36 µSv/h.

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