The International Journal of Engineering and Science (IJES)
|| Volume || 14 || Issue 11 || November || Pages || PP 28-35 || 2025 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Study of the surface water quality in the Ploiesti municipality area

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ABSTRACT

Water has become one of the most important issues of our time, closely intertwined with global warming and population growth. Managing water supply and conserving water resources remains one of the most challenging yet fascinating issues of our era.
This paper has a multidisciplinary character, relying on documentation and fundamental knowledge from fields such as physical chemistry, analytical chemistry, biology, computer science, and even mathematics.
Water quality is one of the most important factors of a healthy ecosystem and can vary from one location to another, depending on the condition of the water source from which it is drawn and the treatment it undergoes. It is conventionally assessed by comparing the physical, chemical, biological, and, of course, bacteriological characteristics of a water sample with guidelines or standards for water quality.

KEYWORDS;- *Water quality, pollution, standards, resistivity, TDS, conductivity, dissolved oxygen, salinity, turbidity.*

Date of Submission: 01-11-2025 Date of acceptance: 10-11-2025

I. INTRODUCTION

The conservation, protection, and improvement of the aquatic environment, especially when water resources are used over a sustainable period, are based on certain principles, the most well-known being prevention, precaution, and the mitigation of damage to water sources. Water quality is a crucial aspect of the effective management of water resources. Improving water quality management is considered essential for a more balanced and multidimensional approach to research, policymaking, governance, operations, and the overall management of water resources.

To maintain the quality of water resources, the most important measures involve activities focused on the prevention and control of accidental pollution.

Water pollution represents the greatest threat to our planet and to the lives of future generations. Each year, approximately 5 to 12 million metric tons of plastic enter the ocean. Carbon emissions produced by human activities - such as driving cars - cause ocean warming and an increase in water acidity levels. This is extremely harmful to marine animals and organisms, as the acid can break down shells and damage coral reefs. [1]

Sources of pollutants from various environmental compartments, such as agriculture (fertilizers, pesticides, herbicides, and animal waste), urban waters (stormwater runoff, sewage, and wastewater), and industry (chemical discharges, thermal pollution, oil spills, petrochemicals and hydrocarbons) are usually interconnected. High levels of pollution can have cascading impacts on both terrestrial and aquatic ecosystems downstream.

Water and wastewater treatment technologies are constantly evolving, giving rise to an increasingly sustainable industry that is one of the largest and most interdisciplinary sectors in the world, involving chemists, microbiologists, botanists, zoologists, as well as engineers, computer specialists, and a wide range of professionals in management. [2]

Drinking water quality standards are designed to ensure the supply of clean and safe water for human consumption, thereby protecting human health. These standards are usually based on scientifically evaluated acceptable levels of toxicity, either for humans or for aquatic organisms.

Pollutants enter water from multiple sources. Industrial and municipal wastewater discharges, contaminated runoff from urban and agricultural areas, atmospheric pollutant deposition, and lake infill are all significant sources of contaminants. Some substances such as chromium, cyanides, chlorides, acids, alkalis, or various metals, occur naturally, and their presence in water can be the result of natural processes. [3,4]

II. MATERIALS AND METHOD

This study was initiated out of a desire to make an objective comparison between the water from rivers surrounding the city of Ploiesti, before and after they pass through the city and, implicitly, through the industrial zones. Through this paper, we aim to highlight the degree of pollution and neglect regarding one of the fundamental resources for our existence, the water, and the way in which we, as humans, influence water quality. These impacts have repercussions not only on vegetation, fauna, and human health, but also on how we relate to one another and to the environment that surrounds us.

Environmental stability is often altered by humans to meet their needs, but in many cases, this behavior leads to pollution of the air, water, and soil, resulting in a decline in quality of life. Surface water quality is a useful indicator of the condition of a region, reflecting the impact of human activities on natural ecosystems.

In Romania, at existing wastewater treatment plants, only 77% of discharged wastewater is treated through urban collection systems. In 47 urban localities with more than 170,000 inhabitants, wastewater is discharged without any preliminary treatment. In 2020, the total volume of wastewater discharged into receiving waters was 5,982.82 million cubic meters per year.

The development of wastewater treatment plants and sewer networks will be carried out gradually, considering that, at the time of accession to the European Union, the implementation of the Urban Wastewater Treatment Directive was considered a complex and highly costly issue. The estimated implementation costs were 9.5 billion euros, of which 5.7 billion euros were allocated for the construction of treatment plants and 3.8 billion euros for the construction and expansion of sewer networks. [5,6]

Description of the sample collection area

The Prahova, Dâmbu, and Teleajen rivers, as well as the Ghighiu Monastery stream, are located near the city of Ploiesti, in Prahova County, a region in southeastern Romania. The county features a particularly diverse landscape, starting with the peaks of the Bucegi and Eastern Carpathians (specifically the Curvature Carpathians group – Baiului, Grohotis and Ciucas Mountains) in the north, followed by the Subcarpathian hills in the center, and the Ploiesti Piedmont Plain (part of the Romanian Plain) in the south.

The northern mountains can be crossed via the Prahova Valley to the Predeal Pass in Brasov, or via the Bratocea Pass along the Teleajen River - both routes leading to Brașov. The vast majority of the county's hydrographic network belongs to the Ialomita River basin, which flows through the southernmost part of the county, forming the border with Ilfov County. The main rivers that flow into the Ialomita and pass through Prahova County include the Prahova River (with its tributary, the Teleajen) and the Cricovul Sarat River.

The sampling locations were distributed along the Dambu, Teleajen, Prahova rivers, and the Ghighiu Monastery spring as follows: one sample before each river enters the city of Ploiesti, namely the samples:

- PD1 - GPS: 44.979563, 25.995479;
- PT1 - GPS: 44.996596, 26.016668;
- PP1 - GPS: 44.924257, 25.826968;

Two samples after the rivers have passed through half of the urban area, the samples:

- PD2 - GPS: 44.943295, 26.047150;
- PT2 - GPS: 44.964516, 26.061534;

two samples after the rivers have passed the city and the initial pollution sources, the samples:

- PD3 - GPS: 44.885701, 26.141220;
- PT3 - GPS: 44.938898, 26.126941;

and the sample:

- PG - GPS: 44.898635, 26.068108, was taken from the spring of the Ghighiu Monastery, Prahova County.

Sampling Methods

Water sampling must be carried out with great care, and the sampling points as well as the timing of sampling must be carefully planned. It is essential that the condition of the samples is of the highest importance in order to obtain reliable results in water analysis.

Samples were collected on February 26, 2023, March 27, 2023, April 24, 2023, and May 4, 2023. Sampling was performed according to standards. All water samples were collected in sterile plastic bottles and stored at 5^0C until analysis. These samples were analyzed without any treatment.

For each sample, seven analytical parameters were recorded, in accordance with European protocols: pH, resistivity, TDS (total dissolved solids), conductivity, dissolved oxygen, salinity and turbidity. The determination of pH, resistivity, TDS, electrical conductivity, salinity and dissolved oxygen was carried out in the laboratory using a Multi 9430 WTW multiparameter device, while turbidity was measured using an MI415 MARTINI turbidimeter. [7-9]

The analytical determinations were performed at the Multidisciplinary Scientific and Technological Research Institute from Valahia University of Targoviste.

III. RESULT AND DISCUSSION

The physicochemical analysis of water aims to determine both the natural components of the water and those introduced by pollution. Water quality control can be performed through routine, comprehensive, or specialized analyses, depending on the intended purpose.

pH Determination

pH represents the concentration of hydrogen ions in a solution, and the pH scale, which ranges from 0 to 14 units, is used to measure the acidity or alkalinity of the solution. Surface waters, which usually contain insignificant amounts of CO_2, typically exhibit basic pH values. Changes in pH are influenced by photosynthesis processes (when aquatic plants consume CO_2, hydroxide ions OH^- are released). Sources of hydrogen ions include humic substances and humic acids, which enter the water together with soil. In surface waters, pH typically varies between 6.5 and 8.5; deviations from these values indicate pollution by inorganic or organic compounds (Table 1). [10-14]

Water with a pH from 0 to 7 is considered acidic, at pH 7 it is considered neutral, and above this level, water is considered alkaline. The pH index does not measure water toxicity; rather, it must be understood in relation to the needs of the human body.

Table 1. The pH results

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	8,18	7,96	7,947	7,577	7,333	7,016	7,316	7,889
03.2023	8,048	7,932	7,996	7,282	7,253	7,298	8,057	8,095
04.2023	8,037	7,87	7,868	7,164	7,182	7,158	8,066	7,988
05.2023	8,13	7,98	8	7,23	7,25	7,27	8,14	7,95

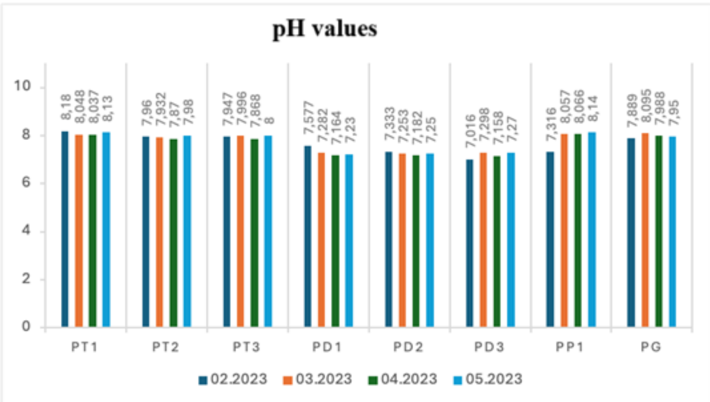

Figure 1. Results of pH determination

Thus, from the comparative analysis of the pH test results, it appears that this parameter falls within the legally permitted limits for almost all the samples considered in the case study.

Turbidity Determination (NTU)

Turbidity comes from the Latin word “turbidus”, meaning disturbed or cloudy. Turbidity characterizes the degree of impurity, lack of clarity, and transparency of water (or any other liquid). Water that is not clear has a certain level of turbidity. Turbidity is one of the most important parameters of drinking water and is caused by the presence of particles (impurities) of organic or inorganic nature suspended in the water that do not settle over time. Quantitative determination of turbidity is performed in the laboratory using a turbidimeter or spectrophotometer. [15]

The measurement of turbidity, called turbidimetry, is an analytical procedure that measures the concentration of an emulsion by comparing its transparency to a standard reference. In Romania, turbidity levels are regulated by Law 458/2002, which sets a maximum of 5 NTU (Nephelometric Turbidity Units), with the specification that water must have a maximum of 1 NTU before entering the disinfection process (Table 2). [16]

Table 2. The turbidity measurement results

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	11,00	19,90	45,00	22,00	30,70	74,00	201,00	2,00
03.2023	12,75	68,00	186,00	16,23	55,00	68,00	294,00	2,83
04.2023	41,60	26,20	85,00	11,90	40,10	22,60	301,00	1,50
05.2023	26,01	39,66	189,00	8,78	42,72	27,44	974,00	0,00

Thus, from the comparative analysis of the turbidity test results, it appears that this parameter does not fall within the legally permitted limits for almost all the samples considered in the case study. A discrepancy can be observed in sample PP1 taken in May 2023, compared to the other samples from the same river, due to the fact that this sample was collected at midday, while the other samples were collected after 6:00 PM. The sampling site is located near a gravel quarry, and during the collection of this sample, quarry activity was at peak operation.

Conductivity Determination

Conductivity represents the ability of a substance or medium to transport a certain amount of electric current. This property occurs only if there are charge carriers in the medium that can move freely. Pure water has an extremely low electrical conductivity (0.037 μS/cm at 18^0C) due to the HO^- and H_3O^+ ions formed through a weak dissociation process. Conductivity increases significantly if ionic species are present in the water; therefore, the preliminary assessment of ion content is done through conductivity measurements (Table 3). [17]

Table 3. Conductivity measurements

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	1062	1481	1472	1270	1275	1453	1000	558
03.2023	1154	948	990	1547	1229	1538	616	548
04.2023	1154	1026	977	1543	1298	1481	637	575
05.2023	1196	1056	1042	1630	1406	1658	633	542

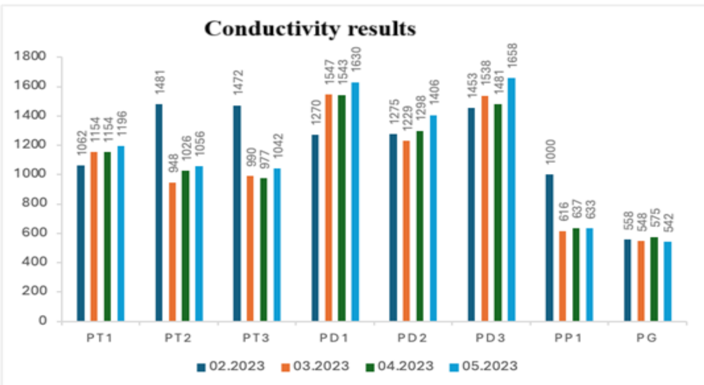

Figure 2. Results of conductivity determination

As we can observe, from the comparative analysis of the conductivity test results, it appears that these parameters do not fall within the legally permitted limits for almost all the samples considered in the case study.

Resistivity Determination

The electrical resistivity of water is measured in [kΩ/cm], which is the inverse of conductivity, and a sudden change in resistivity indicates the appearance of a source of water contamination (Table 4).

Table 4. The electrical resistivity results

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	552	682	641	722	798	645	994	1692
03.2023	866	1054	1010	646	814	650	1623	1843
04.2023	866	974	1024	648	770	675	1570	1740
05.2023	836	947	960	614	960	603	1579	1845

TDS Determination

TDS stands for Total Dissolved Solids and represents the total amount of dry substance (dry weight %) - mineral and/or organic - remaining after the complete evaporation of water at 105^0C. According to the World Health Organization regulations, the TDS level for drinking water should be at least 100 mg/L, ideally between 200–400 mg/L, with a maximum allowable limit of 500 mg/L (Table 5).

Table 5. TDS results

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	1.862	1.479	1.472	1.269	1.274	1.455	1.002	551
03.2023	1.154	948	990	1.547	1.228	1.538	616	548
04.2023	1.151	1.026	976	1.542	1.298	1.482	637	574
05.2023	1.194	1.054	1.044	1.631	1.406	1.658	633	542

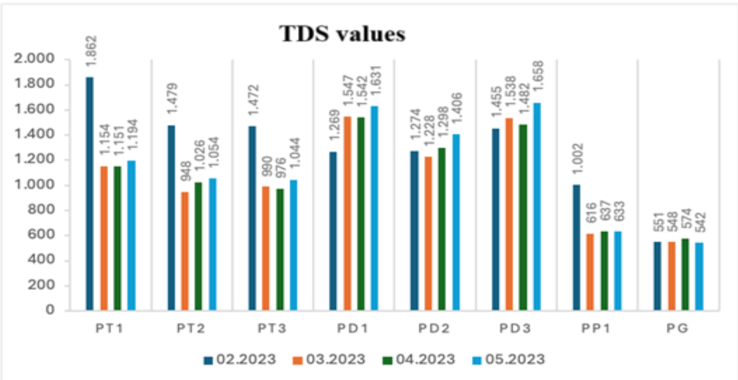

Figure 3. Results of TDS determination

As we can observe, from the comparative analysis of the TDS test results, it appears that these parameters do not fall within the legally permitted limits for almost all the samples considered in the case study.

Salinity Determination

The chloride content in drinking water generally reflects the salinity of the water. Water analysis that determines salinity levels is especially important for deep waters and coastal areas, where infiltration can cause a salty or bitter taste. Water with high salinity affects installations and household appliances due to its highly corrosive nature and is not recommended for consumption (Table 6).

Table 6. Salinity results

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	0,80	0,60	0,70	0,60	0,80	0,60	0,70	0,20
03.2023	0,50	0,40	0,40	0,70	0,60	0,70	0,20	0,20
04.2023	0,50	0,40	0,00	0,70	0,60	0,70	0,20	0,20
05.2023	0,50	0,50	0,50	0,80	0,70	0,80	0,20	0,20

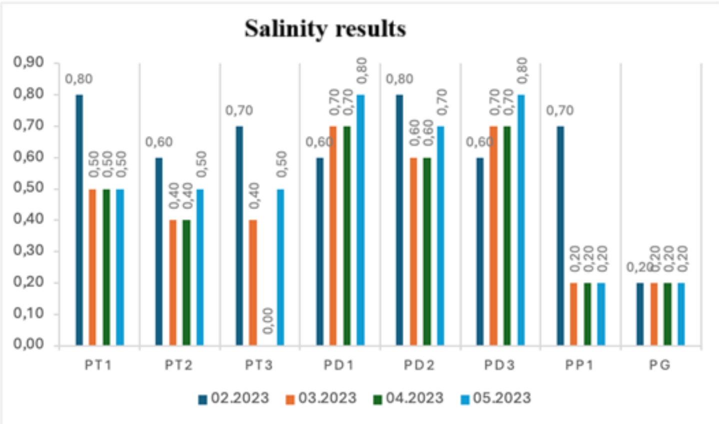

Figure 4. Results of salinity determination

As we can observe, from the comparative analysis of the salinity test results, it appears that these parameters fall within the legally permitted limits, with few exceptions, for almost all the samples considered in the case study.

Dissolved Oxygen Determination

The amount of dissolved oxygen in water depends on the water temperature, air pressure, and the content of oxidizable substances and microorganisms. A decrease in the oxygen content of water leads to the loss of freshness, resulting in a flat taste and making the water undrinkable. Additionally, the reduction of oxygen decreases the self-purification capacity of natural waters, favoring the persistence of pollution with all its undesirable consequences. The concentration of dissolved oxygen in water is extremely important both in nature and for humans. Dissolved oxygen plays an essential role in the growth and development of life in aquatic ecosystems such as oceans, lakes, rivers, and other surface waters. Without oxygen, water can become toxic due to the anaerobic decomposition of organic matter.

In aquatic environments, a dissolved oxygen level of at least 5 mg/L promotes healthy growth of most fish species. Conversely, water in boilers and heating systems should not contain more than 10 mg/L of oxygen. To regulate the oxygen content in water, ozonation installations or other specific devices can be used (Table 7).

Table 7. Dissolved Oxygen results

DATE	PT1	PT2	PT3	PD1	PD2	PD3	PP1	PG
02.2023	3,00	8,70	7,90	8,23	2,41	0,98	8,97	5,21
03.2023	8,65	8,64	8,63	0,94	2,05	1,29	8,38	8,53
04.2023	8,24	8,34	8,14	4,61	3,24	3,19	8,46	8,88
05.2023	8,48	8,37	8,15	2,25	2,13	0,23	7,99	8,22

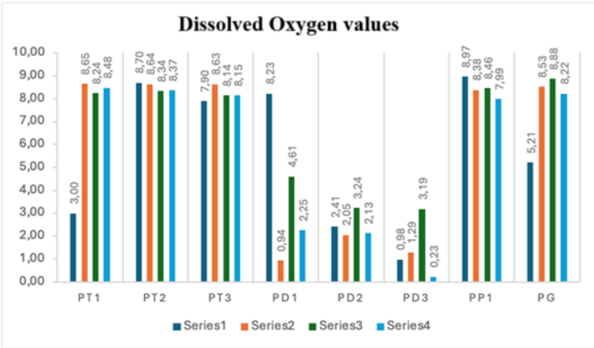

Figure 5. Results of dissolved Oxygen determination

As can be observed, from the comparative analysis of the dissolved oxygen test results, it appears that these parameters fall within the legally accepted limits, with minor exceptions, for approximately all the samples considered in the case study.

IV. CONCLUSION

Our water resources, unevenly distributed in space and time, are under increasing pressure due to demographic changes and growing demand. Access to accurate and reliable data on water availability, quality, quantity, and their variability forms the essential foundation for the healthy and sustainable management of water resources. It is necessary to clearly understand and quantify all components of the hydrological cycle, as well as the impact of human activities on it, to effectively protect and utilize these vital resources.

Environmental components such as water and its sustainability are crucial for all living organisms and the future of our planet. All organisms in an ecosystem are interconnected, and water, as the primary source of life, is a fundamental and irreplaceable element. The major challenges humanity has faced in recent years, related to the quantity and quality of water, highlight the importance of protecting and responsibly using this essential resource.

In the context of sustainable progress, monitoring water quality and the environment holds a fundamental place in protecting water resources. It is increasingly evident that water is not only an essential source for life in general but also a vector for the spread of pollution on both local and global scales. The water monitoring process requires the establishment of rules and procedures regarding data collection methods, responsible parties, data aggregation methods, and the types of resources used for monitoring (such as informational and material resources).

This study focused on certain literature reviews, relying primarily on specialized books, articles published in internationally and nationally recognized journals, and specific standards regarding the control and monitoring of water quality.

To determine water quality, it was necessary to consult multiple scientific works and to develop a monitoring and validation program through the evaluation of certain performance indicators and the use of data analysis tools such as limit of detection, precision, accuracy, quantification, method sensitivity, measurement uncertainty of water samples, and others.

Speaking in general terms, only a small volume of wastewater is treated. The increasing demand for water and the discharge of mostly untreated wastewater represents a major challenge for integrated water resource management. Direct reuse of untreated wastewater, as well as the use of freshwater resources polluted with wastewater in agriculture, are very common in urban and peri-urban areas.

Despite the positive impact on local economic aspects, with significant socio-economic benefits from irrigated areas, the public health risks are undeniable. Therefore, wastewater and biosolids/sludge are important resources that can help in the fight against water, food, and energy crises. The use of wastewater, excreta, and domestic wastewater in agriculture offers opportunities for recycling water and nutrients and can have a positive environmental impact by preventing pollution.

Alternative wastewater treatment methods based on the principles of circularity and several unconventional technologies for wastewater can be implemented for both individual and collective sewer systems. Designing a series of cost-effective solutions that address the technical, institutional, social, behavioral, and cultural barriers to adopting such an approach remains one of the major challenges.

In other words, a significant portion of the wastewater we produce ends up directly in sensitive water bodies, where chemicals and all other organic and inorganic compounds can affect the environment in ways we cannot fully predict but are most often negative.

This is due, among other factors, to the undersizing of sewer networks, insufficient connections to treatment plants, and the inadequate number of treatment plants.

A long-term strategy that proceeds step by step is necessary, as well as the creation of new local business models. The wastewater cycle is generally regulated by legislation, including what can and cannot be discharged into public sewer systems, supported by specific infrastructure, both private, through pre-treatment plants and various filtration installations and public, through water treatment plants.

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