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INVESTIGATION OF DRINKING WATER QUALITY CHANGES IN THE DISTRIBUTION NETWORK OF IASI CITY BY MEANS OF AN ON-LINE MONITORING SYSTEM

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Abstract

Drinking water produced in water treatment plants almost invariably fulfils the water quality requirements set, for example by the European Union Drinking Water Directive 98/83/EC (EU DWD) and national legislation. However, EU DWD requires that water quality should also meet the requirements at the consumers' tap. The quality of drinking water changes due to the transportation through the distribution networks and the time spent in the reservoirs until the last point of consumption. Water companies face major problems related to the quality of the drinking water at consumers' tap, even if they invest important financial resources for catchments, treatment and disinfection. Aesthetic and organoleptic problems are the main reasons for customers to complain about the water quality supplied. Turbidity is one of the quality indicators causing most of the water quality problems. Nowadays, modern water management must tackle in an integrated way the law requirements and the new technologies and instruments which help water companies identify the cause of any events occurring in the supply networks, in terms of real-time monitoring. These problems are also valid for Iasi County, situated in the North-Eastern part of Romania, where water supply and wastewater treatment are managed by *SC Apavital SA*, a county-wide public-owned company which has the task of providing high-quality water and related services for customers, while complying with strict regulations.

This study presents the application of an on-line monitoring system for real-time, continuous monitoring of turbidity in the Iasi city distribution network, as well as the efficiency of on-line turbidimeters for water quality monitoring in the effluent of the treatment plant and for water quality changes in the distribution system. By evaluating the data gathered during the on-line monitoring of turbidity for this case study, it is possible to detect abrupt changes in water quality and thus to react to any disturbances in the system by adequate corrections in the treatment stages.

Key words: distribution network, water quality monitoring, water supply

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1. Introduction

Water networks in Romania comprise pipes of concrete, cast iron, ductile iron (lined and non-lined), steel, asbestos cement, uPVC, polyethylene, and glassfibre reinforced plastic. With the exception of some recent investments, distribution network pipes are old (dating back over the last 100 years), of poor manufacture and networks are in a poor condition as evidenced by the high levels of network leakage (between 30 and 50%). There are no cathodic protection systems in place, so metallic pipes are subjected to external corrosion in aggressive soil areas. Systems are generally open and operated within pressure control zones, although little is done in terms of pressure reduction to reduce network losses. Limited system inspection is carried and network management is reactive and generally of a manual nature (EU and Romanian Government, 2008). As a consequence, water companies receive between 3000

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and 6000 customers complaints about poor quality water, annually. Of all the indicators, turbidity is causing most of the water quality failures. These historic factors are the key for understanding the levels of services and the processes leading to the occurrence of high turbidity events which are associated with the mobilization of accumulated particles from within the distribution networks. Such particles have probably different origins, either from external sources or from processes occurring within the system.

The most common processes associated with the phenomenon of high turbidity in distribution networks is historically the corrosion of cast iron pipes as is suggested on the site of the Public Health National Institute (Romanian Government, 2004a; 2004b). Many authors who studied the corrosion of cast iron in drinking water systems concluded that this is a major cause of high turbidity water (Smith et al., 1997; McNeill and Edwards, 2001). Recent studies (Prince et al., 2003; Vreeburg, 2007) have suggested that other sources besides corrosion play a role for the high values of turbidity. Particles originating during treatment are also identified as the source of deposits in the network. A recent statistics showed that 10% from the total of 601 water treatment plants in Romania which each supply water for more than 5000 people exceed the admitted level for turbidity by standard regulations (Public Health National Institute, 2010).

The presence of colloids (and associated turbidity) in drinking water begins from the treatment plant and the water quality in the distribution network is for sure heavily dependent on the performance of the water treatment stages (especially of coagulation-flocculation, sedimentation filtration and activated carbon adsorption for the surface water influents). However, the treatment processes performances are also dependent on the source water quality, groundwater not necessitating from this point of view many treatment stages. Particles (such as suspended solids or colloids) can have attached pathogenic organisms or natural organic matter (NOM), that sometimes may pass through filters, or may prevent good contact between the micro-organisms and the disinfectant, or can react with a disinfectants (especially chlorine) to form by-products that may be detrimental to human health (Hendricks et al., 2005; Han et al., 2009; Jagatheesan et al., 2009). Optimal coagulation-flocculation and sedimentation processes before filtration insures that the water going to the filtration stage will have a low turbidity and a relative small number of suspended solids and colloids (Teodosiu, 2001; Teodosiu and Stanciu, 2001). A failure in coagulation-flocculation may have severe consequences for the water treatment and for the entire water supply system, e.g. poor removal of particles, pathogens and natural organic matter (Eikebrokk, 2009). Similarly, a failure in the removal efficiency of turbidity or particles by granular activated carbon processes can decrease the inactivation efficiency of the disinfection processes. Controlling the treatment processes and treated water quality to minimize the amount of deposits-forming components (Vreeburg, 2007) leaving the water treatment plant will be helpful in preventing high turbidity events, tastes, odors and the proliferation of microorganisms in the distribution network. Gauthier and his collaborators (Gauthier et. al, 2001) concluded that even in highly treated water, particulates can be introduced into the distribution system by the effluents of the treatment plants.

In ensuring the supply of safe drinking water, the distribution system is as important as the water resources and treatment facilities. The water quality changes between the time drinking water leaves the treatment plant and the time it arrives at the consumers tap. Drinking water distribution systems work as continuously fed reactors in which physicochemical (chlorine consumption, flocculation, particles sedimentation, corrosion etc.) (Kirmeyer et al., 2000; Stephenson, 1989) and biological reactions (biological growth) (Le Chevallier et al., 1987; van der Kooij, 2000) are carried out in the bulk and at the interface bulk/surface. The change of water quality is also dependent upon the type of network (transport or distribution), the material used and the hydraulic regimes (Vreeburg, 2007). All of these mentioned particulate water quality mechanisms contribute to the accumulation of material in the distribution network (storage) that can and will be re-suspended incidentally (Verberk et al., 2009). Once the chemical and biological deposits (biofilms) form in the system, pseudo-equilibrium takes place between the water column and the inner walls of the pipes (Le Puil, 2004), leading water with a relatively stable quality and complying with regulations. However, when this equilibrium is disturbed by changes in the hydraulic conditions (flow direction and velocity), these deposits can be resuspended (Vreeburg, 2007), which implies a new equilibrium. These mechanisms are often misunderstood and are always difficult to control.

2. Particularities of monitoring systems and control of water quality

Water companies are required to check their water quality by analyzing samples taken from the water treatment plants and distribution system. The minimum number of analyses for check monitoring is defined in EU DWD. The sampling frequency depends on the size of the treatment plant, e.g. for the largest treatment plant producing more than 100,000 m^3/day of water, DWD requires that check monitoring should be done virtually on a daily basis (Council Directive 98/83/EC, 1998). However, even this frequency is not sufficient for detecting abrupt but transient events that nevertheless create major disturbances in drinking water distribution system.

Water quality in a Romanian distribution system is monitored for three types of group indicators by the water companies and reported to the Ministry of Public Health through the Public Health

Authorities, at county level. These three groups of indicators (microbiological, chemical and physical indicators) are defined in Drinking Water Law no. 458/2002, amended and revised by Law no. 311/2004, which was harmonized with the European legislation. According to the Romanian Law no. 458/2002*,* the values currently in use for drinking water quality indicators are the same as those provided by the EU DWD. Even if these parameters don't have a direct health background, they are meant to provide information over the production processes from source to tap. If any of the indicator parameters has a value higher than specified in Law no. 458/2002, the water company needs to investigate the reason and to undertake the necessary measures so as to comply with the standards.

Drinking water monitoring covers all localities in Romania, but the number of analyzed water quality indicators is limited in many localities. The water quality as it leaves the treatment plant and in the distribution system is traditionally monitored by turbidity measurement and disinfectant residual concentration. Law no. 458/2002 allows a maximum value for turbidity leaving the treatment plant of 1 NTU, and occasionally values up to 4 NTU are accepted in the distribution network. The water quality, including turbidity measurements, is checked on a regular basis by *grab sampling*. Despite a number of advantages, this procedure has considerable limitations in terms of: a) temporal and spatial resolution that may be achieved at reasonable costs, and b) the information on bioavailability that may be obtained. Manual sampling is labor intensive, and the number of samples that can be collected is limited by personnel and analysis costs. In addition, grab sampling can only show the water characteristics at the time the samples were taken. Important events (e.g., night-time events) that occur between samples are not depicted or unusual results may be dismissed (Premazzi and Hargesheimer, 2002).

The major problem, in terms of public health protection, is that the monitoring of drinking water safety is reactive, in the sense that any event or breakdown in the system can occur many hours, before it is detected by monitoring for any of the routinely measured parameters. Nevertheless, laboratory analytical instruments can provide definitive confirmation of the presence of potential contamination in the drinking water and are routinely used for compliance monitoring. Because these instruments and associated, analytical approaches are designed for compliance monitoring activities, the total analysis times can be quite lengthy and may not be compatible with the goals of on-line monitoring during a water contamination emergency (Hall et. al., 2007).

While traditionally measured indicators have proved useful and still play an important role, the establishment and use of emerging tools as part of monitoring programs may complement monitoring already in place by providing additional information with the aim to obtain a more representative picture of the water quality and the needed measures to adapt treatment stages operational parameters.

Moving from grab-sampling to *real-time, on-line monitoring* is essential for more expeditious and accurate water quality assessment. An on-line monitoring system is an integrated system for monitoring, analyzing, interpreting, and communicating monitoring data, which can be used to make decisions that are protective of public health and minimize unnecessary concern and inconvenience to the public (US EPA, 2005). In order to make monitoring systems more efficient, according to Maasdam and Ungureanu, (Maasdam, 2000; Ungureanu et.al., 2010) water quality monitoring systems should be a balanced combination of data collection and information generation. The connection between the data collected by monitoring and its use within water management is an important element in the success of any (water quality) monitoring application.

The data from an instrument vary over time for several reasons as depicted in Fig. 1. To interpret a set of measurements as an indication of a contamination event requires a thorough understanding of the changes that arise in the system operation (for example, opening or closing of valves, flushing of major systems, adding disinfectant etc.) and what characteristics can be used to differentiate the contaminants

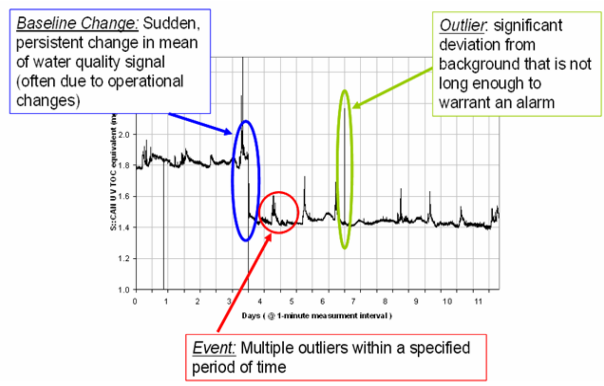

Fig. 1. Examples of different types of changes in a water quality signal (US EPA, 2010)

It is more useful for water companies to consider how to control the processes taking place within the distribution system, so as to minimize the customers' risks for being exposed to contaminated drinking water. This concept considers the water distribution system as a linkage of processes working together to maintain flow, pressure, and water quality (pumping, metering, transmission, distribution, service, storage, and corrosion control).

High turbidity events are difficult to study in real systems because they often occur over short periods seemingly for unpredictable reasons and the changes in the levels of quality indicators are subtle. In such events, the measurable indicator requiring investigation is turbidity, which is a measure of colloids/suspended solids and of the degree to which water loses its transparency due to their presence. During the transport through the networks particles are lost due to settling or produced by corrosion or biofilm formation resulting in a difference between the incoming and the outgoing water and, consequently, a difference in the turbidity reading (Vreeburg, 2007). Thus, continuous turbidity monitoring in distribution systems is used to monitor the water quality, analyze the movement of particles and to estimate the associated high turbidity events. An interpretation of data from continuous monitoring of turbidity, as is it given by Vreeburg (Vreeburg, 2007), is presented in Fig. 2, 3 and 4. In Fig. 2, the effect of settling is demonstrated in the decreased turbidities. The residence time can be determined when the peak value at the treatment plant is followed in the transport on distribution network (Vreeburg, 2007). In Fig. 3, resuspension as a result of increased velocity during peak hours is presented. In this case a typical morning peak causes a relatively sharp increase of turbidity. The increase is highest in the distribution network (Vreeburg, 2007). Fig. 4 presents the case when in the transport network the same turbidity as in the treatment plant occurs. The pattern in the distribution network is typical for *active corrosion*: increase during night hours with almost stagnant water that is flushed during the monitoring peak resulting in a lower turbidity. The model presented by Vreeburg will be used in this study for the investigation of drinking water quality changes in the distribution network system of Iasi City by means of information produced by continuous turbidity monitoring.

The data provided by the on-line monitoring system will be used to find information that will enable the decision making process by the management team or the information on water quality issues and the necessary adjustments in the treatment stages.

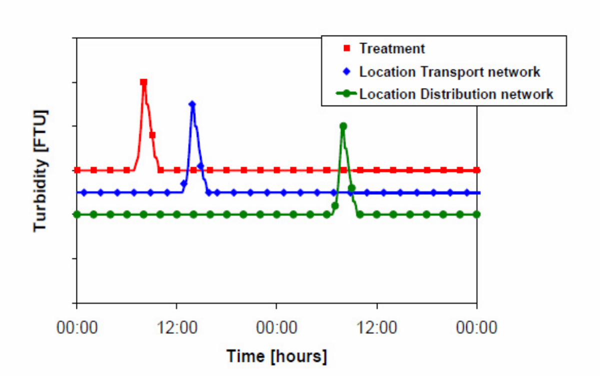

Fig. 2. Stylistic patterns of continuous turbidity monitoring for three locations

The main objective of this study is to present by means of a case study, how a drinking water monitoring system can facilitate the information system up-grade and the decision making process so as to meet the regulatory requirements, while also providing information for operational treatment processes modification. This study is part of a much broader research effort which aims at developing various management instruments in order to improve the decision making processes within water quality management.

The case study will include: presentation of the supply system and on-line monitoring system in Iasi city, an analysis of the data gathered during continuous monitoring of turbidity (based on Vreeburg model), and the development of a response plan related to high turbidity events (detected through the continuous monitoring of turbidity) and their management.

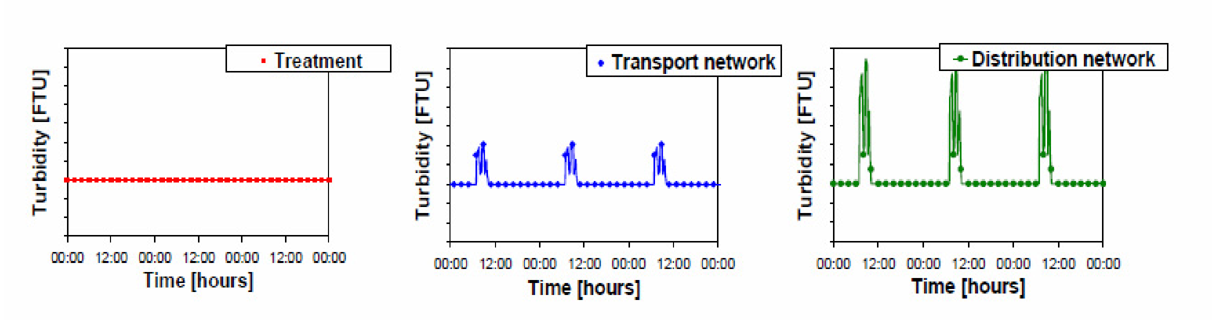

Fig. 3. Stylistic patterns of turbidity monitoring

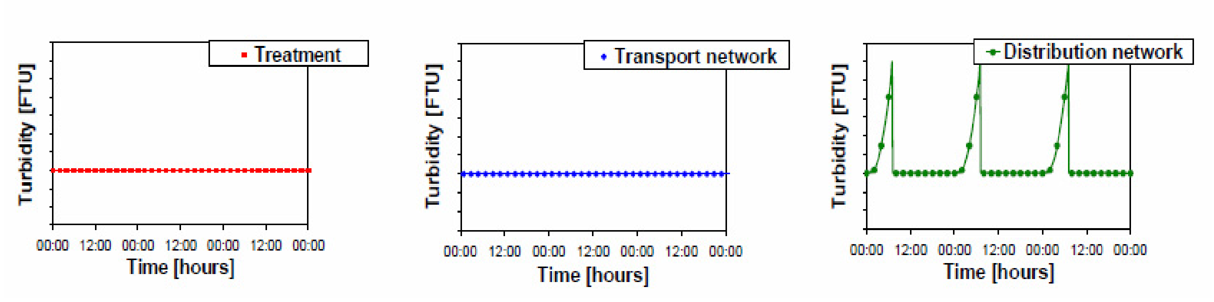

Fig. 4. Stylistic patterns of turbidity monitoring

3. Methodology

3.1. Iasi City water supply system

During the last years, considerable efforts were undertaken to develop a monitoring system for both water flow and quality in Iasi city. Water quality assessment efforts in the past were centered on periodic collection of discrete ("*grab*") samples and their laboratory analysis and retrospective data interpretation. Starting with 2007, an on-line monitoring system has been installed in the drinking-water supply network of Iasi, in cooperation with Duinwaterbedrijf Zuid-Holland, in the framework of the project "*Implementation of a monitoring system in the drinking-water supply network of Iasi*". This system is designed to support and supplement the water quality control performed by punctual analysis on the distribution network. Thus, the monitoring system is used to detect abrupt changes in water quality, while the punctual analysis (carried by laboratory) check the compliance with quality standards of the water delivered to consumers and the fact that it does not create risks to human health. The goal of the on-line monitoring is to gather information to improve the knowledge about the supply network to support operation and maintenance decisions for a final water quality compliant to the legislation.

The water supply of Iasi city is achieved from two major water sources: "Timişeşti Drains", ground water source, at about 100 km west of Iasi with a maximum daily flow of 1,500 l/s, and Prut River surface source, at about 56 km east of Iasi with a 3,500 l/s flow. For the Timisesti source only disinfection is applied as treatment, since this underground source is characterized by very low contents of colloids, organic and inorganic compounds, the biological quality indicators being also much lower as compared to surface water (Teodosiu and Stanciu, 2001). This water source has been in operation since 1906.

Water from Prut River needs adequate treatment (grit removal, pre-oxidation, coagulation-flocculation, sedimentation, rapid sand filtration, activated carbon filtration, chlorination) due to the fact that it contains dissolved (inorganic, organic) and suspended material, colloids, microorganisms and plankton. The natural quality of surface water is dependent on the nature of the soils crossed over and the municipal, industrial and agricultural pollution that comes from upstream. Thus, insufficiently treated municipal wastewaters, accidental discharges of industrial effluents or pesticides used in agriculture can contribute to a depreciation of the source quality and can further decrease the efficiency in the water treatment plant (Teodosiu and Stanciu, 2001). Usually the Prut - raw water is suitable for drinking purposes (after treatment), but after heavy storms and in spring (due to the melting snow) the turbidity is often too high and makes treatment more complicated. Water has to be pumped from the intake in the Prut River to Chirita Lake and subsequently it is transported to the Chirita treatment plant. Before distribution, water is disinfected by chlorination.

In the distribution network the two sources (Timisesti and Prut) are interconnected and because of technical conditions there is no clear-cut separation between them. As the water distribution network in Iasi is quite old (it was established starting with 1911 and developed in time), important drawbacks are mentioned: *depreciation of drinking water quality* and *water losses*. The age of the network and the material in which it is made (63% steel) are reasons for important leakage (42% of the supplied water) in the network (Dorus, 2008), with negative impact on the supplied water quality indicators. Therefore, water quality is affected in a negative way and there is also the risk for contaminated ground water to penetrate the pipes, through cracks. The water supply of Iasi city has extended in time as a response to the water demand of the social and economical development of the town, and depending on the possibilities of supplying the required flows.

3.2. Monitoring areas and locations

APAVITAL, the water company in Iasi city and county, has selected a zone for monitoring that is located in the urban area south of the Bahlui River, see Fig. 5. The water supply network in the selected area had been divided into 3 micro-sectors (different colors in Fig. 5 and Fig. 6) which are continually monitored at **17** (stationary) points of measuring (*pressure, flow, residual chlorine, turbidity, conductivity*) located at strategic places in the distribution system. The monitoring locations are indicated in the map of Fig. 5.

The locations of cabinets containing monitoring equipments were chosen so as a number of conditions to be fulfilled:

- the covering of the entire area that has been selected for the pilot project implementation (the interference area of the two water sources);
- measurement results to be representative;
- easy and safe access of maintenance personnel;
- sound access to utilities;
- preserving the physical safety of equipments against damages and vandalism.

Monitoring data are read at selected locations and data are logged and transmitted regularly (1 reading for all indicators per 5 minutes) to a central receiving unit at the APAVITAL Iasi head-office. Transmission is made by mobile telephone using the GSM network. The monitoring system is a data acquisition system (storing sensor readings on *Proficy Historian* data management software for analyzing historical data.

The quality monitoring system presented here consists of three types of Endress+Hauser sensors that monitor the water turbidity (CUS41), conductivity (CLS21) and free chlorine (CCS140) variations in time.

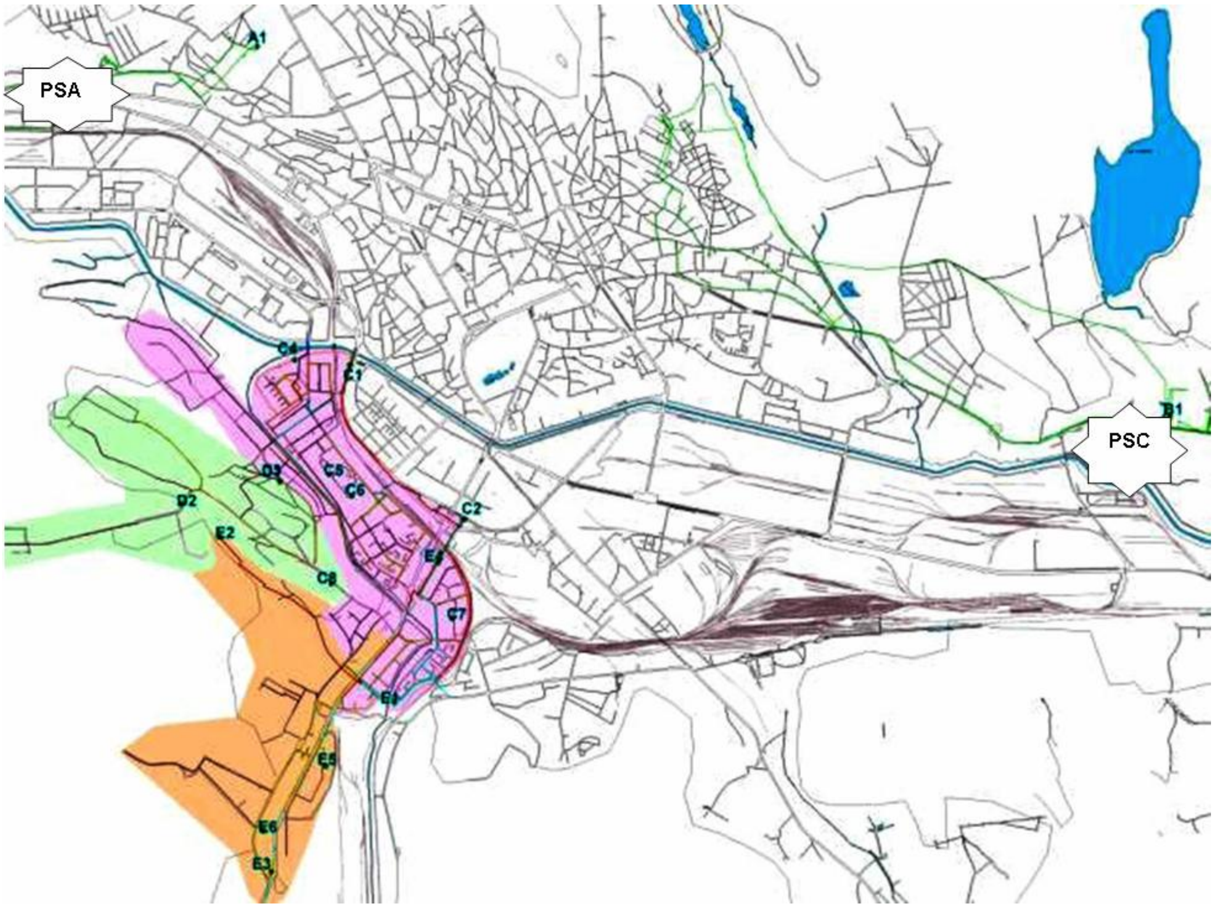

Fig. 5. Monitored area and locations

Legend: PSA–Aurora pumping station; PSC–Chirița pumping station; C1–CFR; C2–Bazar; C3–Galata pumping station; C4–Grădinița nr. 24, C5–Băile Nicolina; C6–Grup școlar special deficiențe motorii ; C7–Biserica Sf. Antonie; C8–Cimitir Sf. Vasile; D2–Rezervor Galata; E1- SP CUG; E2–Rezervor Miroslava; E3–Rond CUG; E4–Bloc Nicolina; E5–Școala gen. nr. 42; E6–PT 13 CUG

4. Results and discussions

4.1. Data interpretation

In Figs. 6-12, the turbidity parameter traces in the two points where the water enters the distribution network Iasi, the Chirița PS (Chirita treatment plant for Prut River source) and the Aurora PS (pumping station and disinfection point for Timisesti groundwater), and also in three other relevant points of the network: CFR (transport network), CUG PS (pumping station with secondary disinfection) and PT 13 CUG (end of distribution network) are drawn in graphs with the measured parameter on the vertical axis and time on the horizontal axis.

Chirita Treatment Plant monitoring (the treatment plant for Prut River source)

In Fig. 6, the blue line illustrates a typical pattern of turbidity at the Chirita treatment plant. A low and consistent level of turbidity (0.2 to 0.3 NTU), on the plant effluent, indicate the adequacy of treatment processes during the monitored period (Oct. 2009). Nevertheless during 2009, the monitoring of the particles levels in the plant effluent had repeated peaks over 1 NTU (Fig. 7), fact that indicates the presence of certain factors- along the process stream– that are influencing the water final quality. Some of the particles present in treated water may be organic or inorganic compounds that naturally exist in the water source and which may enter the distribution system due to an incomplete retention of suspended solids/colloids along the treatment process, while others may be added to the water by the treatment plant itself, along the treatment processes, such as carbon, sand, alum or iron flocks. Given that insufficient removal of particles during coagulation, flocculation, sedimentation and filtering processes may affect the disinfection effectiveness, there is the risk of water-borne diseases caused by germs attached to particles. Moreover, several researchers (Ellison, 2003; Kirmeyer et al., 2000; Slaats et al., 2002; Vreeburg, 2007), have shown that the particles originating from the treatment plant play an important and potentially dominant role in the generation of deposits in distribution systems. Therefore, optimization and improvement of treatment processes with respect to the short peaks in turbidity and particle content during filter ripening, hydraulic steps and particle breakthrough is necessary.

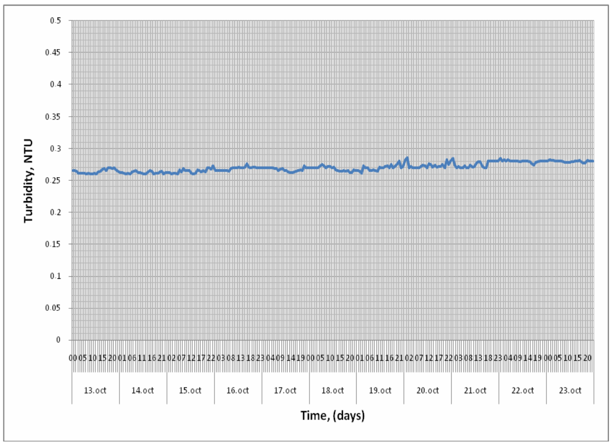

Fig. 6. Turbidity variation, October 2009, Chirita PS

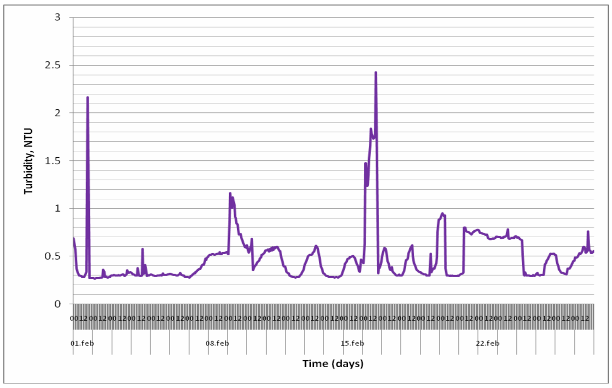

Fig. 7. Turbidity variation, February 2009, Chirita PS

By controlling the treatment processes and treated water quality so as to minimize the amount of deposits-forming components and microbial nutrients leaving the treatment plant prevents water discoloration, tastes, odors and the proliferation of microorganisms in the distribution system.

Aurora Pumping Station (PS) monitoring (pumping station and disinfection point for Timisesti ground water)

When analyzing the data recorded at the other entry point of water towards the Iasi distribution network (the Aurora PS), for turbidity it has been found a constant increased load in colloids, with values of 1 to 1.5 NTU and peaks ranging between 2 and 2.5 NTU (Fig. 8).

This has been caused, most likely, by the accumulation and the resuspension of sediments that have build-up in the tank. At PSA water comes from Timisesti groundwater source at about 100 km of Iasi, this long pipeline is supplying also other communities/villages along the way. This water source has been in operation since 1906 and the transport network is quite old.

Consequently, there are deposits in the pipes and at the end of the long transportation network, turbidity is increased as a result of resuspension that mostly can be related to increased velocity of the water. This was requiring, in compliance to health and hygiene norms, a periodical cleaning of the tank. From the investigations carried out it has been found that the tanks have been cleaned for the last time one year ago.

In addition to the microbiological risk generated by the possibility of germs attached to particles (and of which destruction by disinfectants can be prevented by this association), a drinking water containing high particles loads at the network inlet is a sediment source that leads to silt build-ups in the network.

Also, as it has been outlined above, some of these particles may be organic, thus affecting the effectiveness of disinfection (by increasing the amount of residual chlorine concentration in water needed to ensure a residual chlorine load and the possibility of occurrence of disinfection by-products).

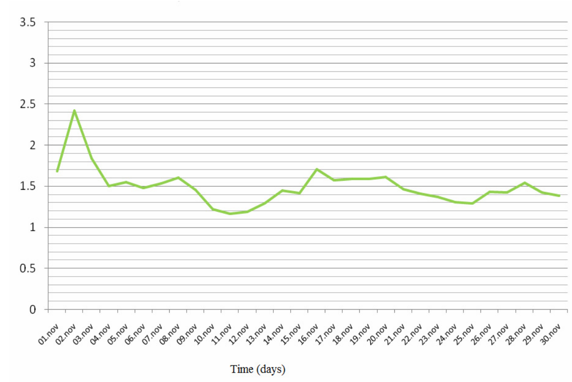

Fig. 8. Variation of turbidity at Aurora PS, November 2009

CFR monitoring (transport network)

Following the line that traces the turbidity variation in the immediately next monitoring point after the pumping station Aurora, „CFR”, there is an obvious decrease in turbidity (Fig. 9).

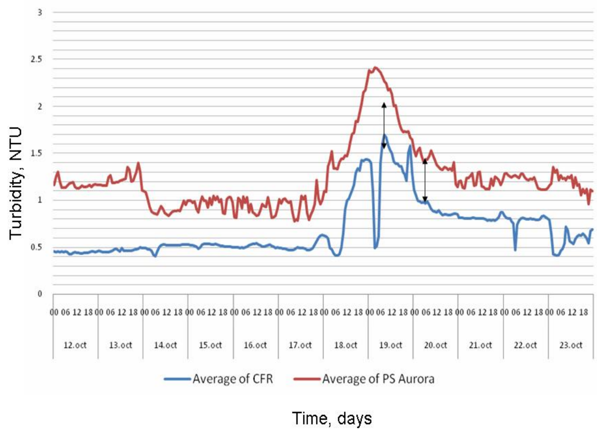

Fig. 9. Turbidity variation at CFR, October 2009

This observation is consistent with the fact that turbidity decreases in the direction of water flow due to particle sedimentation on the pipes.

In the same time, the instability of distribution conditions (pressure, flow/velocity) in this location, is leading to a variable quality/turbidity of drinking water.

The increased water velocity due to hydraulic events (valves opening, pumps start-ups, etc.) leads to a resuspending of particles accumulated in the pipe, and hence, to turbidity peaks.

In Fig. 10 it is presented, as an example, the situation recorded in „CFR" location, on December 3rd, 2009, when an increase of water velocity increased the turbidity level up to 3.8 NTU. This maximum has been transmitted through the network and could be noticed and monitored in the following points – „PS CUG" and „PT 13 CUG".

The peaks in the turbidity can be used as natural tracers to monitor the residence time in a network. The peak values at each location are used to identify the origin of water and that "*package*" of water can be followed through the network. This has proven to be a very powerful tool to actually measure the residence time without adding tracers to the water.

The monitoring of turbidity peaks can be a useful tool for determining the residence time of water in network, average velocity of water during transport respectively, if distance between locations is known.

PT 13 CUG monitoring (end of distribution network)

The measuring point „PT 13 CUG" can be presented as a typical water quality monitoring of the distribution network. This location in the distribution network is on the smaller sized pipes, 150 mm and smaller, at which the house connections are made. In fact this is the water that actually enters the properties and is used by the consumers.

The level of turbidity in this location is influenced by the water demand throughout the day. Thus, during the days in which there is an increased consumption of water, an increased turbidity is noticed (due to the resuspending of particles accumulated in pipes as presented in Fig. 11).

That is in accordance with the observation that for the majority of time the turbidity drops indicating that material is lost from the fluid and probably settling at the pipe wall. An increase in velocity will increase the sheer stress and resuspend the settled material.

The fact that there were recorded peaks of over 2 NTU, indicates a significant build-up of sediment in the network (Fig. 12) and the necessity for its cleaning.

4.2. Response plan elaboration

Based on the information produced by means of data provided during continuous turbidity monitoring, the possible causes of the events (high turbidity) corresponding to each discussed location have been identified, in order to prevent these events in the future.

The required actions to minimize or to eliminate the event consequences have been proposed (as presented in Table 1).

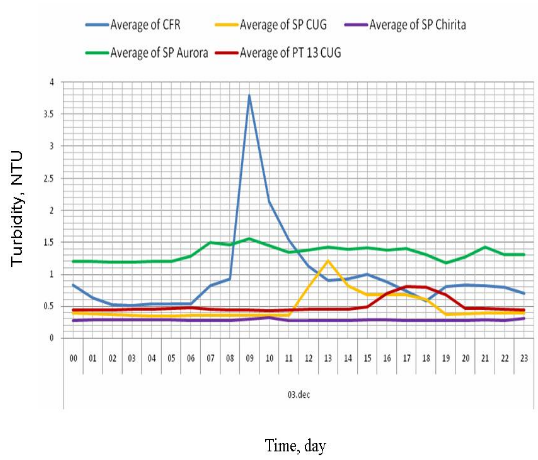

Fig. 10. Variation of turbidity in network measured points

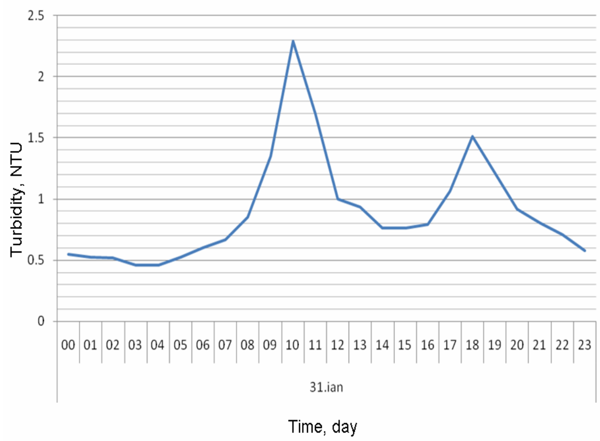

Fig. 11. Turbidity hourly variation at PT 13 CUG

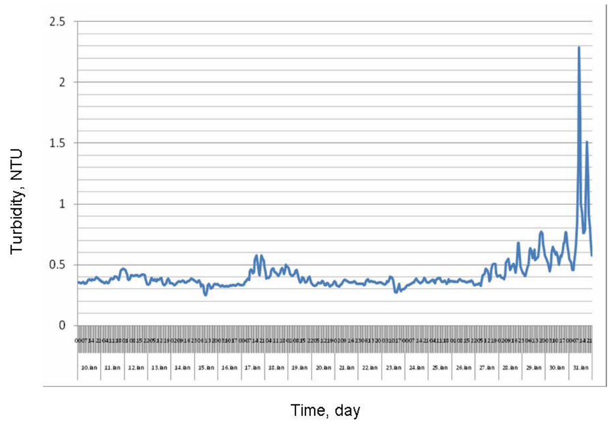

Fig. 12. Variation of turbidity in PT 13 CUG

5. Conclusions

This study presents the application of an on-line monitoring system for real-time, continuous monitoring of turbidity in the Iasi city distribution network, as well as the efficiency of on-line turbidimeters for water quality monitoring in the effluent of the treatment plant and for water quality changes in the distribution system.

Table 1. Response plan

Location	***Event detected***	***Information produced***	***Suggested action***	***Motivation and description of the action***
Chirita Treatment Plant	High turbidity level in the plant effluent	The presence of certain factors- along the process stream- that are influencing the water final quality	The development of a study focused on the effectiveness of treatment processes within Chirița treatment plant. The proposed study should provide more insight into the Chirita treatment plant processes and the impact, if any, of pollution events as they move through the water treatment processes. The main objective is to optimize the plant performance through identification and subsequent reduction of particle events that occur prior to filtration or during the backwash cycle.	The main objective for a drinking – water treatment plant is to produce drinking water with a constant excellent water quality. To achieve this objective, the water quality influent and the process characteristics must be taken into account during the treatment plant operation. Since this plant is part of a water system, any change in the operating conditions due to variation of production flow (water demand) and seasonal variations of flow and/or water quality at source (temperature, precipitation, drought and algae growth) will generate disturbances that can impact on the final quality of treated water. As the possibilities of elimination/reduction of disturbances that occur in a certain process stage are limited, these disturbances are propagated through the consecutive treatment steps. Thus, the performance of a treatment step will affect the efficiency of the subsequent steps. For example, a failure in coagulation-flocculation-sedimentation processes can have severe consequences for the filtration (unsettled particles, if very small and un-flocked, can pass through filters or clog them rapidly) resulting in a poor removal of particles, pathogens and natural organic matter (NOM). Similarly, a failure in the removal efficiency of turbidity or particles by filtration processes can decrease the inactivation efficiency of disinfection processes (the NOM shall demand extra amounts of water disinfectants, this determining, in some cases, the generation of disinfection byproducts). This may decrease water safety and result in distribution problems as well, e.g. solids deposition, corrosion, re-growth and biofilm formation.
Aurora Pumping Station	High turbidity level at the exit of pumping station	There are significant build-up of the sediment at the bottom of the tank, consequently the tank should be cleaned	The undertaking of a study with the objective to analyze the influence of particulate matter upon the effectiveness of disinfection process and water bio-stability. This investigation will consider also the proposal of a monthly schedule to determine the frequency of tank cleaning together with a monitoring program for relevant water quality indicators to justify the re-growth potential.	This future study will require the determinations on water and sediment samples collected during the process of tank cleaning and also during normal distribution conditions, before and after the tanks washing. The material collected should be examined for: TSS, VSS, turbidity, $Mn2+$, $Fe2+$, $Al3+$, Si, HPC, total-, heterotrophic- and coliform bacteria. The microbiological analyses should be carried out on the samples before and after blending to expose particle-associated microorganisms to the water column. To study the overall tendency of the water to promote or suppress microbial proliferation (water bio-stability), the assessed indicators to justify the regrowth potential should be: assimilable organic carbon (AOC), biodegradable dissolved organic carbon (BDOC), dissolved organic carbon (DOC), adenosine triphosphate (ATP), ultraviolet absorbance at 254 nm (UV254), specific ultraviolet absorbance (SUVA), total coliforms, total heterotrophic bacteria, free chlorine, biofilm formation rate.
PT 13 CUG	High turbidity event during the increased consumption of water	There is a significant build-up of the sediment in the distribution network	Drafting of a working procedure in order to determine how to achieve the cleaning and the disinfection of pipelines and the time intervals.	There would be considered both new non-commissioned pipelines, and, as well, the existing pipelines, according to a monthly schedule of cleaning and disinfection. Cleaning should be carried also after planned interventions (carried for damages on the public water system). These cleanings should be carried with strict compliance to service quality rules, and to all laws related environmental and safety and health at work.

This approach represents a considerable step that has to be taken by many water companies interested in providing very good drinking water quality to the consumers.

The data provided by the on-line monitoring system can be used to find information that will enable the decision making process by the management team or the information on water quality issues and the necessary adjustments in the treatment stages. The on-line monitoring system is a valuable "tool" that generates information which provides a good knowledge about the quality of the water and mechanisms on water quality changes in different location in the distribution system. Understanding of these processes itself will not immediately improve the water quality in the distribution network, but it will give the possibility to prioritize areas of intervention and to take effective measures to optimize the infrastructure and performance of the water distribution system, as well as of the treatment stages. The water monitoring system can facilitate the information system up-grade and the decision making process so as to meet the regulatory requirements, while also providing information for operational treatment processes modification. In this case, the elaboration of a response plan was a necessary measure so as to remediate the identified problems in future, at the level of the treatment plant or of the distribution network.

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