INVESTIGATION ON WATER TREATMENT PLANTS: "CASE OF RROGOZHINA AQUIFER"

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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled “INVESTIGATION ON WATER TREATMENT PLANTS: “CASE OF RROGOZHINA AQUIFER” and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

INVESTIGATION ON WATER TREATMENT PLANTS: “CASE OF RROGOZHINA AQUIFER

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The problems regarding the quality of water are becoming more and more disturbing as the pollutants area of action is expanding. Bacteria, chemical and physical aspects of water pollutants are inevitable part of most of water sources. As it is very important to have a clean and good quality source of water in the first chain of water supply systems, in some circumstances, this may not be possible for many reasons. In this part, Water Treatment Plants come in hand. The choice of the plant should be made after numerous analysis and tests, cost estimations and calculated needs.

Keywords: *Aquifer, Water Treatment Plant, Chemicals, Bacteria, Process, Flow, German Degrees.*

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CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Water is the most essential substance on Earth, even though it is a renewable source. We use it everyday for indoor and outdoor purposes and most importantly it serves a number of essential functions in our body. We are about two-thirds water and still require water to live. Babies are born 78% water. A year after this percentage drops to 65% while adults bodies are 60% water. (The Water in You: Water and the Human Body)

Since the water itself is critical for people well being, the methods of its purification and supply are critical as well. The water supply chain is complicated and each link has a great importance to the expected output. Water is taken from the chosen source, purified, and than it goes from distribution line to costumers.

In deciding the most favorable source and creating the water supply network, the first step is defining the water quality. Water quality describes how good the water is by testing the water and measuring the values of its chemical, physical and microbiological components. If the values fulfill the standards set for each country, the water is suitable for use.

1.2 Thesis Objective

In this thesis, will be introduced different types of Water Treatment Plants used in most developed countries. After explaining how they work and their advantages and disadvantages, a comparison will be made between them for which fulfills the most the required parameters and cost efficient to accomplish our goal.

The main objective is to determine the best Water Treatment Plant for Rrogozhina Aquifer in Albania. As most of the country has a great capacity of wells which have good water quality, unlike many other countries advanced technology is not necessary.

1.3 Organization of the thesis

This thesis is divided in 5 chapters. The organization is done as follows:

In Chapter 1, the problem statement, thesis objective and scope of works is presented. Chapter 2, includes the literature review. Chapter 3, consists of the methodology followed in this study. In Chapter 4, the case study and and Chapter 5 results and discussion. In Chapter 6, conclusions are stated.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The quest for pure water started in 1676, when Van Leeuwenhoek first observed water micro organisms. Later on, in 1700 filters made of wool, sponge and charcoal were firstly applied. The first victory of creating a whole system of water treatment belongs to Scotland, where Robert Thom built it in 1804. It was based on slow sand filtration and then horse and cart distributed the water. (Enzler)

In 1854, to fight the spreading of cholera through water, John Snow, used chlorine for the first time to disinfect the water. This led to a new system of filtering water and the waterborne diseases became less and less common. (Enzler)

Although the beginning of the 21st century, in the field of water treatment for consumption, is the period of development of membrane processes, traditional water treatment plants will have to be used for several more decades. However, they must be constantly rehabilitated, transformed and supplemented with modern techniques to suit the quality requirements.

In accordance with the World Health Organization Standards, the great majority of population health risk caused by water comes from its microbiological aspects such as bacteria, viruses and parasites. However it does not exclude the risk of chemical and physical aspects which are a huge concern after a prolong period of exposure. (World, 2008)

The risk from chemical aspects originates from natural sources and industries and agriculture practices. As mentioned earlier the chemical aspects can cause a serious damage health after a prolong period of exposure. This means that people can not feel its effects right away and by the time they understand the problem, the damage will be done. (World, 2008)

Hardness is one of the most important chemical parameter since it is linked with calcium and magnesium carbonates and bicarbonates (which can be removed by boiling) and calcium and magnesium sulfate and chloride (which can be removed by chemical precipitation using lime and sodium carbonate). Hardness in water is objectionable because calcium and magnesium sulfate have a laxative effect and hard water makes lathering more difficult, and so it increases soap consumption. (Rural Water Supply, 2012)

Alkalinity and Acidity is the presence of acid substances is indicated by pH below 7.0 and alkaline substances by pH greater than 7.0. Acidic water is corrosive to metallic pipes. Carbon Dioxide is the presence of appreciable quantities of carbon dioxide makes water corrosive due to carbonic acid formation and the presence of free CO2. (Rural Water Supply, 2012)

Dissolved Oxygen aside from a flat taste, water devoid of oxygen may indicate an appreciable level of oxygen-consuming organic substances. Chemical Oxygen Demand (COD) is a measure of the amount of organic content of water. As bacteria utilize oxygen in the oxidation of organic matter, the COD increases and the dissolved oxygen in the water decreases. (Rural Water Supply, 2012)

Organic Nitrogen is a constituent of all waste protein products from sewage, kitchen wastes and all dead organic matter. Freshly produced waste normally contains pathogenic bacteria. All water high in organic nitrogen should therefore be suspected for possible contaminants. Toxic Substances are a number of chemical substances, if present inappreciable concentration in drinking water, may constitute a danger to health. These toxic substances include arsenic, barium, cadmium, hexavalent chromium, cyanide, lead, selenium and silver. (Rural Water Supply, 2012)

Groundwater usually contains more Iron and Manganese than surface water. Iron and manganese are nuisances that must be removed if in excess of 0.3 mg/l and 0.1 mg/l respectively. They stain clothing and plumbing fixtures, and the growth of iron bacteria causes strainers and screens to clog and metallic conduits to rust. The appearance of a reddish brown or black precipitate in a water sample after shaking indicates, respectively, the presence of iron or manganese. (Rural Water Supply, 2012)

While the chemical aspect determining is almost impossible without testing, physical aspects are easier to tell. Although the risk is lower, they should be monitored. These parameters are taste, turbidity, color and odor. Turbidity should always be low, especially where disinfection is practiced. High turbidity can inhibit the effects of disinfection against microorganisms and enable bacterial growth. (Rural Water Supply, 2012)

Drinking water coloration may be due to the presence of colored organic matter. Organic substances can also cause water odor, though odors may result from many factors, including biological activity and industrial pollution. Taste problems relating to water could be indicators of changes in the water source or in the treatment process. (Rural Water Supply, 2012)

Turbidity is a measure of the degree of cloudiness or muddiness of water. It is caused by suspended matter in water like silt, clay, organic matter or microorganisms. Even when caused by factors that do not pose a health risk, turbidity is objectionable because of its adverse aesthetic and psychological effects on the consumers. (Rural Water Supply, 2012)

Color is due to the presence of colored substances in solution, such as vegetable matter and iron salt. It does not necessarily have detrimental effects on health. Color intensity could be measured through visual comparison of the sample to distilled water. (Rural Water Supply, 2012)

Odor should be absent or very faint for water to be acceptable for drinking. Pure water is odorless; hence, the presence of undesirable odor in water is indicative of the existence of contaminants. (Rural Water Supply, 2012)

On the other hand, microbiological aspects are diverse in characteristics, behavior and resistance. The diseases they produce have the greatest risks to humans health and are more common and widespread comparing to other aspects. In the table below is given a general information on pathogens, their types, significance, persistence in water and most important, their relative infectivity.

Table 1 Pathogens transmitted through drinking-water. (World, 2008)

Pathogen	Type species/genus/group	Health significance	Persistence in water supplies	Resistance to chlorine	Relative infectivity
Bacteria					
Burkholderia	*B. pseudomallei*	High	May multiply	Low	Low
Campylobacter	*C coli*	High	Moderate	Low	Moderate
	C. jejuni				
Escherichia coli – Diarrhoeagenicg	*E. coli* O157	High	Moderate	Low	Low
		High	Moderate	Low	High
Francisella	*F. tularensis*	High	Long	Moderate	High
Legionella	*L. pneumophila*	High	May multiply	Low	Moderate
Mycobacteria (non-tuberculous)	*Mycobacterium avium* complex	Low	May multiply	High	Low
Salmonella typhi		High	Moderate	Low	Low
Other salmonellae	*S. enterica*	High	May multiply	Low	Low
	S. bongori				
Shigella	*S. dysenteriae*	High	Short	Low	High
Vibrio	*V.cholerae* O1 and O139	High	Short to long	Low	Low
Viruses					
Adenoviridae	Adenoviruses	Moderate	Long	Moderate	High

Astroviridae	Astroviruses	Moderate	Long	Moderate	High
Caliciviridae	Noroviruses, Sapoviruses	High	Long	Moderate	High
Hepeviridae	Hepatitis E virus	High	Long	Moderate	High
Picornaviridae	Enteroviruses, Parechoviruses, Hepatitis A virus	High	Long	Moderate	High
Reoviridae	Rotaviruses	High	Long	Moderate	High
Protozoa					
Acanthamoeba	*A. culbertsoni*	High	May multiply	High	High
Cryptosporidium	*C. hominis/parvum*	High	Long	High	High
Cyclospora	*C. cayetanensis*	High	Long	High	High
Entamoeba	*E. histolytica*	High	Moderate	High	High
Giardia	*G. intestinalis*	High	Moderate	High	High
Naegleria	*N. fowleri*	High	May multiply	Low	Moderate

These pathogens have properties that differentiate them from other water contaminants. Firstly, they can cause acute and chronic health effects. Pathogens can grow in the environment and are discrete. And last but not the least, pathogens if infection is established, they multiply in their host. (World, 2008)

In order to remove these hazards and to improve the water quality, Water Treatment Plants come in hand. As they are used worldwide and have given great results in solving a problem that affects the majority of the population, they are now proved to be the best solution.

Determining the best surface water treatment plant to produce a drinking water in accordance with applicable norms is not always easy for several reasons. Surface water sources can very rarely be of very good quality.

Classes 1A and 1B defined according to the European water classification, occupy more and more a smaller percentage compared to class 2 (which allows the production of drinking water only after a very advanced treatment) which constitutes the largest percentage .Consumption water norms are strict (compared to other food ingredients of the population) and it is increasingly difficult to satisfy.

Consumers are becoming more and more demanding about the taste of water and their demand for mineral water forces handlers to produce water without bad taste and especially without chlorine taste. According to public health norms, the water treatment plant must disinfect the water before and during distribution (except in exceptional cases).

Consequently, the lack of taste of chlorine can be obtained only by adding small amounts of chlorine and its derivatives and having a very good quality water, which imposes an efficient treatment.

The available processes are more and more diverse and their function is not unique. Some of them, in fact, may fully or partially satisfy many quality objectives, although the optimal operating conditions may not be in line with these different objectives.

Preliminary laboratory tests to determine a strainer are in some cases complicated and difficult, and results at the end of these tests are often costly and not always reliable.

2.2 Water Quality Standards

The main task of Water Treatment Plants is to adjust the water parameters to the required levels in Guidelines. Each country has its own standards when it comes to water quality. The majority has adapted their standards with the World Health Organization's, with small modifications conform their conditions.

The tables below describe the drinking water standards of World Health Organization and United States Environmental Protection Agency. As it is shown the major value difference is in Total Dissolved Solids, a parameter which affects the taste of the water. Low TDS level water has a flat, insipid taste and its high levels cause nausea, vomiting and dizziness.

Table 2 The WHO Standards for drinking water (World, 2008)

Chemical parameters	**WHO**
pH	8.5
TDS (mg/L)	700
Free Cl2	0.5
Fe (mg/L)	0.3
Mn (mg/L)	0.1
Zn (mg/L)	5
Cu (mg/L)	1
Al (mg/L)	0.1
Cd (mg/L)	0.003
Cr (mg/L)	0.05
Pb (mg/L)	0.05

Table 3 The EPA Standards for drinking water (Safe Drinking Water Act)

Chemical parameters	**EPA**
pH	6.5-8.5
TDS (mg/L)	500
Free Cl2	0.4
Fe (mg/L)	0.3
Mn (mg/L)	0.05
Zn (mg/L)	5
Cu (mg/L)	1
Al (mg/L)	0.05-0.2
Cd (mg/L)	0.005
Cr (mg/L)	0.1
Pb (mg/L)	0

Water supply comes from two sources. Surface water, which include rivers and lakes and has elevated levels of soil particles and algae that makes it turbid. The second source is Groundwater which includes the water stored below the earth surface. While Groundwater is made of constant composition and has high mineral content, Surface water is made of variable composition has a low mineral content. (Sophocleous, 2002)

Moreover, Groundwater is characterized of its low turbidity, low color and low D.O and Surface water is quite the opposite. Although the biggest difference is that Surface water has taste and odor (physical aspects) and Groundwater high Fe and Mn (chemical aspects), both of them can be contaminated by toxic chemicals. (Sophocleous, 2002)

In general, there are two major types of surface water: Strong and moderately strong waters, with low concentrations of organic matter. They are river waters, which like all running water can be polluted by ammonia nitrogen, nitrates and pesticides and Soft and very soft waters, generally rich in organic matter, which may be flowing or stagnant with different micronutrient contents.

This allows their differentiation into two subclasses. The first one are water leaks which can be polluted by pollutants as a result of human activity, such as pesticides, nitrates, or sometimes ammonia nitrogen (on the outskirts of cities). At their source, some of these waters can be untouched by any kind of pollution including natural organic matter.

And the second subclass are reservoir waters which, due to eutrophication phenomena, are loaded with iron and manganese of natural origin, often concentrated in ammonia nitrogen and rich in algae. The following table presents the three types of water (A, B and C) with the trends of the most important analytical parameters for their treatment.

Table 4 Water pollutant parameters (World, 2008)

Parameters	Strong waters River (type A)	Soft waters	
		River (type B)	Reservoirs (type C)
pH	stable (between 7.5 and 8.5)	Variable (up to 10)	Variable (up to 10)
Mineralization	high (TAC and TH = 15 – 25 °F)	Low (TAC and TH = 1-5 °F)	low (TAC and TH = 1-5 °F)
Content in organic matter	Low (1 – 5 ppm)	high (up to 10 – 15 ppm)	high (up to 25 ppm)
Possibility of NH4 + contamination	average	average	high
Possibility of NO3- pollution	high	high	low
Possibility of contamination by pesticides	high	high	low
Content in iron and manganese	high	low to average	high
Algae development	low	high	high

2.3 Water Treatment Processes

Water treatment is a very complex process. This complexity requires a number of measurements and testing before deciding the appropriate treatment system. As mentioned above, water quality factors are great in number, therefore a number of processes are needed to remove all these hazards from water.

The first step of this process is the pathogen removal. By following the guidelines, after testing the water that has to be treated, is crucial to determine the coliform values, which later will show which treatment is required. (Gray, 2014)

If the coliform values are >100 cfu 100 mL−1, processes as pre-chlorination, coagulation and flocculation, filtration and post-chlorination are mandatory. But there are many cases in which coliform values are <10 cfu 100 mL−1, in which post-chlorination is enough. (Gray, 2014)

In general, this first step includes a number of processes, all subdivided into categories. Pre-treatment starts with coarse screening, pumping, storage, fine screening, equalization, neutralization, aeration and ends with chemical pre-treatment. After all these processes Primary treatment comes in hand. It includes coagulation, flocculation and sedimentation. (Gray, 2014)

Coagulation is the first link of water treatment chain, coming prior to sedimentation and filtration. Scientifically, it reduces the electric repulsion that particles have with each other. By adding positive charges, opposite to those of the solids, it neutralizes their charges. Once the charges are neutralized, a collision starts between the small-suspended particles.

Most commonly, these positive particles are Al3+ and Fe3+ salts. When adding these salts, negatively charged substances precipitate and assemble to form larger sizes. Although the need is to remove not to make the impurities bigger, this specific process creates flocks large enough to be settled in sedimentation basins.

To achieve a proper coagulation system a rapid-mix is required. If this mixing is not sufficient the process will be incomplete, while over-mixing does not affect the process. The time this process takes is 1 to 3 minutes. Coagulation is a very simple and cost-effective process.

We should recall that the coagulation-flocculation process aims to eliminate the colloidal suspended matter; it consists of three treatment phases: fast mixing, slow mixing and sedimentation.

During the rapid mixing phase the coagulation process takes place, which consists in the destabilization of colloidal particles, by the addition of coagulant chemical reagents (generally aluminum or trivalent iron salts), which when dissolved in water, react with alkalinity to form compounds. (aluminum or iron hydroxides) in micro flocks form.

The process that takes place during the slow mixing phase, called flocculation, consists of the formation of flocks and their soldering, which come into contact during mixing. The produced flocks capture and connects to the suspended colloidal substance, which then precipitates.

The most preferable solution is developing the coagulation-flocculation process in a single basin. These basins, depending on the typology of the water treatment plant, have the ability to re-circulate the sludge formed in the mixing area, which serve as central core in which the coagulant is placed, forming within a short time larger and more resistant flocks. Compared to split basins, the use of a single basin makes it possible to reduce work volume and reagent consumption.

Water flows through a filter intended to eliminate particles from inside it. The filters are made of layers of sand and rock, and at times, crushed anthracite. Filtration gathers the suspended impurities in water, improving the viability of disinfection. These filters are regularly cleaned by discharging. For medium and large size water treatment plants, sand filters are recommended.

After the filtration process, the treated water will undergo a disinfection process. The amount of hypochlorite to be applied depends on the short-term and long-term water demand for chlorine.

Disinfection is a treatment which makes possible the destruction or elimination of pathogenic microorganisms. This treatment does not necessarily involve sterilization, which is the destruction of all living organisms in a given environment. Disinfection is accomplished by adding to water a certain amount of a chemical product with germicidal properties.

The most commonly used chemical products are: chlorine, chlorine dioxide, ozone, bromine, iodine and potassium permanganate. Disinfection can also be done by physical means such as boiling, ultrasound, ultraviolet or gamma ray. Currently, the most widely used disinfectant worldwide (up to 80%) is chlorine.

However, the introduction of this reagent can lead to the emergence of undesirable side effects, which, in some cases, make the use of other disinfectants mandatory. Thus, chlorine acts on a portion of the organic matter present in the water, leading to the formation of carcinogens (THMs) or odors (chlorophenols). Moreover, chlorine is not strong enough to completely eliminate some highly resistant microorganisms like viruses. In order to eliminate these deficiencies, chlorine dioxide or ozone is used.

These disinfectants, much more potent than chlorine, have as their main drawback their instability (e.g. ozone, since it acts rapidly in water, cannot maintain a residual concentration for a long time), for this reason they are produced at the water production plant.

Among these most used products are gaseous chlorine and hypochlorite. The advantage of using hypochlorite is that it is easy to use and less dangerous for staff. Chloramines react slowly in water; therefore they are used only in those cases when the contact time is long enough. Chlorine dioxide, being an unstable gas, is produced at the site of use.

However, it is gaining more and more use, as it makes it possible to avoid some of the problems that arise from the use of other forms of chlorine. Laboratory tests, which aim to determine the effects of chlorination of a water, are to determine the demand for chlorine and the formation potential of trihalomethanes.

The choice of sodium hypochlorite, results as the most economical choice in terms of cost, but also practical, as the risk of formation of chlorination products is quite low, for the very small organic load that water has. The process consists of chlorination to break-point, and then applying an additional amount to have some residual chlorine in the network within the normal range (0.2 - 0.3 mg/l).

At the entrance and exit of the drinking water treatment plant, there are analytical switchboards for continuous measurement which are equipped with the following instruments. First, pH and temperature gauge; Dissolved oxygen meter; Conductivity meter and Turbidity meter.

The continuous signals of these meters are sent to the central remote control post where they are administered by the SCADA system - (Supervisory Control And Data Acquisition) - (measurement, alarm, notification). The inlet analyzer is located in the respective environment, near the mixing chamber, for measuring the parameters of the inlet water of the plant.

The output analyzer is located in the respective environment, near the collection tank of produced water, for measuring the parameters at the output of the plant, destined for the distribution network. In this way, in case any of the parameters goes beyond the previously set interval, the verification of the causes will be proceeded: in order to always guarantee a water intended for human consumption. The analyzers are placed into the programmed maintenance cycle of the plant, in order to guarantee in each case an accurate measurement.

Also, at the entrance and exit of the plant, two ultrasonic meters with transit time are needed, in order to control the inflow and outflow of the treatment cycle. Ultrasound technology, chosen for flow measurement, provides an error rate of 1% as well as ease of installation. The cost is advantageous in relation to other (magnetic) technologies for the diameters of the pipes used.

The selected transducers are clamp on type, which have an easy installation and maintenance, instead of those with insert process, to avoid drilling the pipe. The inlet meter is located in a manhole, near the flow control valve, in order to measure the flow entering the plant.

The outlet meter is located in a manhole behind the regulating reservoir maneuver chamber, in order to control the outflow of the reservoir destined for the water distribution network.

The continuous signals of these meters are sent to the central remote control post where they are administered by the SCADA system - (Supervisory Control And Data Acquisition) - (measurement, alarm, notification). The analyzers will be entered into the programmed maintenance cycle of the plant, in order to guarantee in each case an accurate measurement.

The final step is the sludge line consisting in sludge thickening tubs and filter-press for sludge dewatering. The hardware architecture of the remote control system envisages the installation of a PLC Master near the building where the water treatment plant room is located, connected by fiber optic cable to the operational center of supervision and control, from where it is possible to manage and command the entire treatment cycle.

The network is distributed from the PLC Master of the building, the room of the water treatment plant, to 5 PLC Slaves located near the equipment, in which are grouped the signals coming from the treatment cycle, mentioned above:

1. Clearing-flocculation
2. Filtering
3. Chlorine disinfection
4. Drinking water regulating tank maneuver chamber
5. Sludge line.

In this way the PLC Master collects the information coming from the field and transmits it to the main Master of the operational center. In case the operating center is out of order, it is always possible to manage the treatment cycle through the PLC Master of the service building.

CHAPTER 3

METHODOLOGY

In this chapter, three basic water treatment plants and their variants for these three types of water will be introduced. These types of water treatment plants are the most preferable to use due to their efficiency and their ease to use.

The selection of the best water treatment plant for a given water quality and the rehabilitation of an old water treatment plant for its adaptation to new source qualities or new customer requirements and applicable norms, are the problems which are addressed here lower. However, the suggested tips should be used as a guide and not as infallible rules, as it is clear that each surface water is almost a unique case.

The final water treatment plant can only be selected after the following actions have been performed. At first the tests related to water quality are needed. Then, acquisition of the basic elements that will be explained in this chapter and some useful details that will be given in the rest of the paper.

Also, given the often negative evolution of source quality and the publication of new European directives, the chosen water treatment plant should be as rigid as possible, and for sure it should be easy to adapt with changes.

Three types of surface water were defined above: Type A: Strong river water (poor in organic matter and often contaminated with pesticides and nitrates); Type B: Soft river water (rich in organic matter and often contaminated with pesticides, nitrates and algae); Type C: Soft reservoir water (rich in organic matter and often contaminated with ammonia nitrogen, iron, manganese and algae).

3.1 Strong river water, water treatment plants (TYPE A)

Water treatment plants for type A water (solid with little organic matter) depend on the pollution of the source and the importance of production compared to other water sources available to use (groundwater in particular), so, eventual mixtures.

3.1.1 Low yield water treatment plants for very little contaminated water

The main purpose of this water treatment plant is to clear (eliminate turbidity) and disinfect water (inactivate bacteria and viruses). It is generally based on a coagulation-flocculation with aluminum polychloride (PCA) process, without pH correction.

Chlorine pre-oxidation is not recommended, due to the deterioration of organoleptic qualities of water and the potential formation of organochlorine compounds, even with water slightly charged with organic matter.

Since water is inherently strong, practically the pH will remain constant during coagulant intake. The use of an aluminum polychloride (type WAC, WACHB, AQUALENC or any other type) is more preferable than aluminum sulfate as the solubility of aluminum polychlorides at a slightly basic pH (7.5 - 8 in this case) is lower than that of aluminum sulphate.

The possibility of injecting CAP in case of an accidental contamination of the source should also be foreseen in the water treatment plant. Disinfection is generally done with chlorine gas or sodium hypochlorite (which needs less storage equipment).

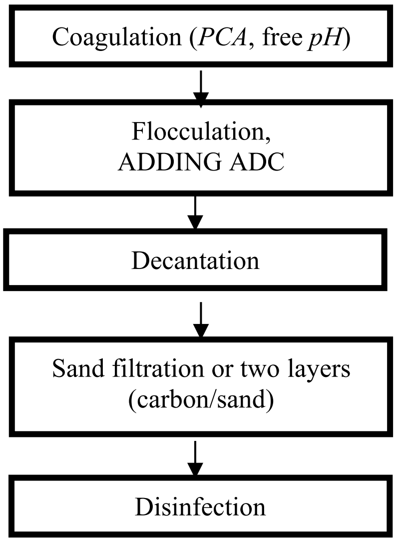


Figure 1 WTP processes for Little contaminated water

3.1.2 Medium and high production water treatment plants for contaminated water

This type of water treatment plant is historically the water treatment plant presented above, to which, over time, have been added (mainly due to deterioration of the source quality), a paraoxidation (often an ozonation), as well as refinishing treatments of based primarily on an intermediate ozonation and a filtration on the CAG.

The main objective is to improve the coagulation-flocculation in relation to the eliminated turbidity, to increase the lifespan of the water treatment plants and saving the reagents. Its amount is generally 0.8 ppm.

Coagulation-Flocculation is performed with aluminum sulfate or aluminum polychloride. The doses used are usually low, as needed for water clarification, for example up to 10 ppm coagulant. CAP injection in this case is necessary, as the pollution, although temporary, can be high. Doses used are from 10 to 30 ppm, maximum 50 ppm.

Nitrification is generally carried out naturally on sand filters. However, in the cold period, chlorine disinfection should be performed. We note that a biological denitrified treatment (rare), for the elimination of nitrates, would be placed before filtration on sand, or, in the case of ion exchange (also rare), after filtration over CAG, only on a part of water.

Intermediate ozonation has three main objectives. The first is disinfection. The second is the transformation of a portion of the residual COD into CODB, which is then eliminated (in part) on water treatment plants with biological CAG. The third is the oxidation of pesticides. The doses used are different (between 1 and 4 ppm). In periods of severe pesticide contamination, injection of hydrogen peroxide (0.5 mg per mg of introduced ozone) is common.

If a high quantity of bromates is observed, then either the pH of ozonation should be lowered, which is not always easy, or the amount of ozonation should be reduced, in both cases to the detriment of the elimination of pesticides. CAP injection and CAG filtration should compensate for this decrease in pesticide elimination efficiency.

The CAG filtration stage in any surface water treatment plant is necessary, especially when it is preceded by an ozonation stage. In fact, it is not advisable to apply ozonation at the end of the thread (post-ozoning) without a biological water treatment plant behind.

Ozonation produces biodegradable organic matter (CODB) which must be eliminated in whole or in part before the distribution of water, to avoid sending to the network of the substrate which would favor the development of the biofilm, as is bacterial growth. Filtration over CAG (biological in this case) represents the ideal support leading to a partial but permanent elimination of organic matter (10 to 30%).

Disinfection can be carried out with chlorine (or derivatives) or even with chlorine dioxide, taking care to always store a certain amount of chlorine in the place (for example where ClO2 is produced), due to the frequent presence of ammoniacal nitrogen, which it is very difficult to eliminate biologically in the cold period.

Some popular variants of this water treatment plant for hard (or medium hard) water include the use of slow filtration on sand instead of fast filtration. Another variant (in the state of the prototype, in 1995) consists in replacing the refinishing stages (ozone and CAG filtration) with a nanofiltration stage, preceded by an acidification (with H2SO4) and sequestrant injection, followed by a pH adjustment (with soda) and by light disinfection.

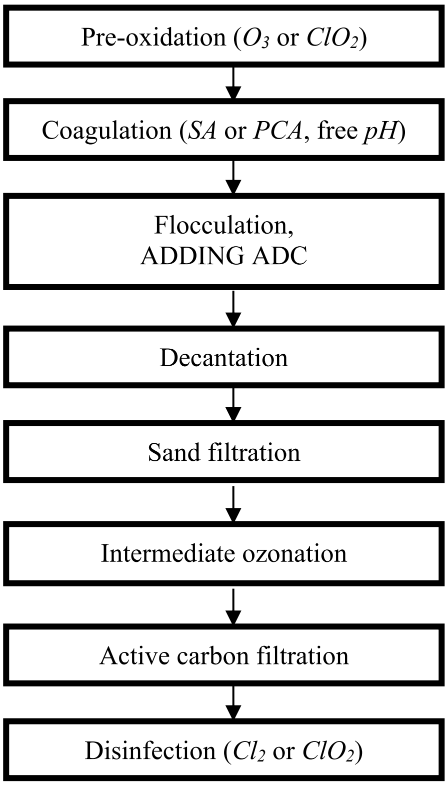


Figure 2 WTP processes for contaminated strong river water

3.2 Soft river water , water treatment plants (TYPE B)

These river waters are characterized by a weak mineralization (calcium TH and low TAC), by an average, sometimes high content of organic matter and are waters exposed to organic micro pollution (especially to pesticides) and minerals (especially to nitrates).

The base water treatment plant for type B waters is built on a ferric iron coagulation at slightly acidic pH. Under these conditions (with 2 mg iron per mg COT or 14 to 15 ppm technical FeCl3 per mg COT) there is a better elimination of organic matter.

Pre-ozonation or pre-oxidation with chlorine dioxide will have as its objective to fight against algae in the hot period. The quantities used will be in the order of 0.5 to 1 ppm, with the problem of chlorite formation (when chlorine dioxide is used) which during ozonation are transformed into chlorates.

Since water is inherently soft, the pH will only drop by the introduction of ferric chloride. However, the addition of sulfuric acid will sometimes be necessary, depending on the amount of organic matter that will be eliminated in the untreated water (evidence may help).

If the coagulant dose is sufficient (about 2 mg Fe / mg COT), there will be no need to increase the pH before filtration. Consequently, ozonation will be done at slightly acidic pH, which will reduce ozone consumption and inhibit bromate formation.

One possible variant of decantation to combat algae is the use of flotation, such as ozofloting. Increasing the pH before the first filtration step will be necessary if the amount of residual iron is high or if pesticides are present in the untreated water. So it must be predicted.

In fact, despite good dosing, iron can be complexed with some organic matter, and in this case, increasing the pH (which leads to the hydrolysis of iron) is necessary. Also, the action of molecular ozone (mainly present at acid pH) is rapid on some pesticides (urea, aldicarb), but not on other pesticides that are more common in water, such as triazines (atrazine and simazine).

In this case, the pH of ozonation must be raised (7.5 to 8), or hydrogen peroxide must be injected (at the same pH and in the amount of 0.5 mg / mg ozone). It is not advisable to increase the pH with an intermediate remineralization (CO2 + lime), as the introduction of bicarbonate would greatly reduce the oxidation effect of pesticides by hydroxyl radicals.

If there is a pronounced appearance of bromates, then the pH should be lowered or the amount of ozone should be reduced; in both cases to the detriment of the elimination of pesticides.

The CAG filtration stage is necessary in all important surface water treatment plants, whether hard or soft, especially after an ozonation stage. Remineralization, is it necessary? At this stage of treatment, the water being aggressive (especially in the absence of pH increase before filtration on the sand), should be put in equilibrium. It should not be forgotten at this stage of treatment that a soft water with a high pH is less likely to triple the lead than a hard water.

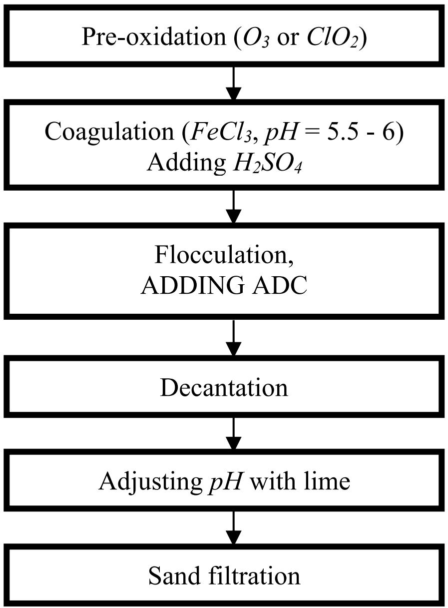
For water disinfection, chlorine dioxide will be preferred, provided that the doses applied are low enough not to lead to high chlorite formation (0.7 mg ClO2- formed per mg ClO2 consumed). The production of chlorine dioxide will be ensured by the chlorine process so that chlorine is available on site in case of ammonia nitrogen contamination.

What should be observed is that in the case of the presence of manganese in water, experience shows that, for this type of water, it is eliminated completely during the clearing stage. In case of a high presence of nitrates, it will be processed in the same way as for hard water. Such water treatment plant requires the construction of corrosion-resistant work.

A variant of the base water treatment plant for type B waters (soft waters with organic matter and pesticides) is the replacement of ferric iron with aluminum sulphate or with an aluminum polychloride (PCA). The coagulation pH should be less acidic than in the first case (pH 6.2 to 6.4), the elimination of organic matter will be smaller and all the advantages associated with it will be reduced.

Also, a pre-mineralization may be necessary if the water is very soft, as the pH becomes very difficult to control in this case, during coagulation, and the risk of increasing the amount of residual aluminum is high. An advantage of this variant is that the reagent dose is lower (1 mg Al per mg COT, or 10 mg powdered aluminum sulfate per mg COT).

An important modification to note between the base water treatment plant and the variant is that the eventual pH adjustment is mainly placed after sand filtration to avoid the presence of aluminum in the water.



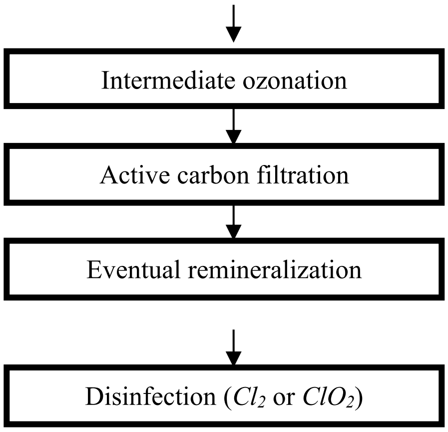


Figure 3 WTP processes for contaminated soft river water

3.3 Soft reservoir water, water treatment plant (TYPE C)

The basic water treatment plant for soft reservoir water, with organic matter, ammonia nitrogen and manganese, is also based on a coagulation-flocculation with ferric iron at slightly acidic pH, with 2 mg iron per mg COT.

Pre-ozonation or pre-oxidation with chlorine dioxide will have the same objectives and will be applied in the same amounts as in the previous case. Placement (auxiliary) of potassium permanganate injection will be provided for "difficult" periods of manganese in untreated water.

As in the previous case, since the water is inherently soft, the pH will decrease simply with the addition of ferric chloride. Addition of sulfuric acid, consequently, will be rare.

Increasing the pH before the filtration stage, in this case, will be more necessary than in the previous case, mainly due to manganese, which in these waters and whatever oxidizing reagent is used, requires the application of relatively high pH high (8 - 8.2), for precipitation and its retention in water treatment plants. F, is preferable to a simple pH increase.

It will have the following advantages. First an increase in TAC (for some waters at this stage of treatment it may be zero) necessary for biological nitrification, for example for the transformation of ammonia nitrogen into nitrates.

Next, stabilization of molecular ozone (in relation to an identical pH without TAC) enabling a better oxidation of manganese. And the last but not the least, improving manganese precipitation in the form of manganese carbonate.

Intermediate ozonation, in this case of water treatment plant, will be placed before sand filtration to eliminate manganese. But are CAG filtration and pre-ozonation necessary? Yes, if there are peak values of frequent pesticides. No, if it is not so and the elimination of organic matter is good in the first stages. As a safety precaution, a two-layer water treatment plant (carbon / sand) can be installed in the first stage of filtration.

The risk of bromate formation is evident in such water treatment plants (high pH ozonation), therefore it is necessary to better adjust the doses of ozone, although this risk is reduced by the presence of ammonia nitrogen in the ozonation stage before sand filtration.

Disinfection with chlorine dioxide in this case is more preferable. Correct use of aluminum sulfate, when there are manganese problems, is relatively difficult, as both metals require very different pH for their precipitation on sand water treatment plants (their precipitation can only be achieved if two filtration stages are used). Such a water treatment plant requires the construction of corrosion-resistant works.

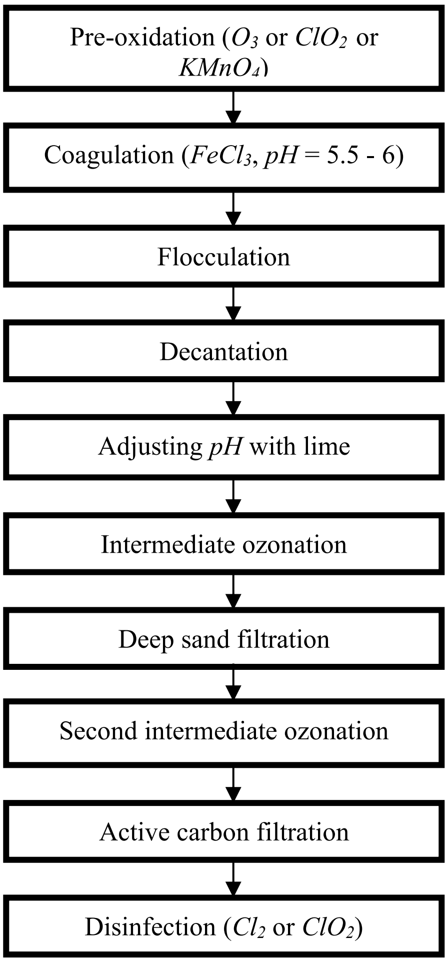


Figure 4 WTP processes for contaminated soft tank water

CHAPTER 4

CASE STUDY

Rrogozhina city has previously been supplied and is supplied with drinking water by its water supply system which needs reconstruction and new wells in order to meet all the drinking water needs of the city. It is worth mentioning that the demographic growth of the city of Rrogozhina and the surrounding areas has required an increase in the amount of water that should be taken into account in the use of reserves of this aquifer.

The Municipality of Rrogozhina is one of the 61 municipalities according to the new territorial division of municipalities in Albania, with an area of 221.12 km2 and includes the district of Rrogozhina.

The Municipality of Rrogozhina is bordered on the north by the Municipality of Kavaja, in the southern part by the river Shkumbin which separates it from the district of Lushnja, on the west by the Adriatic Sea, in the north-eastern part by the Municipality of Tirana and on the east by the Municipality of Peqin.

The assessment of water resources of the Municipality of Rrogozhina is done based on the mapping of aquifers as well as the assessment of hydrodynamic and hydro chemical parameters of groundwater.

The classification of aquifers is done according to the groundwater way of circulation. According to this criteria, aquifers are divided into: Aquifers through which water circulates through the pores (intergranular porosity), Aquifers through which groundwater circulates through different types of voids (porosity mixed) and Not Aquifers.

Intergranular porosity Aquifer with very high water permeability is represented by Holocene deposits: alluvial, sand, gravel, Pleistocene - Holocene aleurolite deposits: sand, gravel (mixed - alluvial). Dusty aquifers with very high water permeability occupy a very small surface 0.13 km2 or 0.1% of the area of the Municipality of Rrogozhina. This aquifer is considered among the aquifers with very high aquifer potential, but in the municipality of Rrogozhina it occupies a negligible area.

Intermediate porosity aquifer with medium - low water permeability is represented by Holocene deposits: sediments, sand, gravels, Pleistocene - Holocene aleurolite deposits, sand, gravel (mixed - alluvial). Medium-low permeable aquifers occupy an area of 43.96 km2 or 20% of the area of the Municipality of Rrogozhina.

This aquifer is associated with the quaternary alluvial deposits of the Shkumbini River. Intermediate porosity aquifer with medium - low water permeability extends to the right of the Shkumbin River from Rrogozhina and continues west to Kalush.

Alluvial deposits generally represent the teraces of the Shkumbin River. The sandy teraces are represented by the present day riverbed of the Shkumbin River and a few meters beside it. The first terace above the pebble has a height of 4 - 6 m and is found almost everywhere.

The second terace has partial spread and is distinguished for its great height represented from gravel, sand and small amount of clay. The lithological composition of gravel deposits is mainly represented by magmatic rock formations and limestone. Sand is everywhere the accompanying element of gravel.

Gravels come to the surface on both sides of the Shkumbin River, and moving away from it, they are covered by a small thickness of clay and mud. The average thickness of the clay cover from east to west, as well as from the river going to the north increases from 1 - 3 m.

The thickness of gravel deposits is increasing towards the west, it has an average thickness of 8 - 12 m to 25 m. The gravel horizon undergoes a gradual softening from east to west.

Generally it has waters with sub artesian pressure, but drilling can be made without pressure, this is conditioned by the thickness of the clay cover and the distance from the river. From the results of exploration works we conclude that quaternary alluvial deposits have specific inflows q = 0.08–0.3 l / sec / m. Drilling flows range from 0.57 - 2.8 - 16 l / s. Drilling depth reaches up to 30 m.

The chemical composition of the waters of this complex is somewhat heterogeneous. HCO3 ions of Mg, Na + K are predominant, but Cl ions can also be present in small composition. The total mineralization fluctuates around the value 586 - 820 g / l, the total hardness is about 15.4–24.6 German degrees. Groundwater is fed through gravels in the north-east part of the layer where the river flows over the gravels as well as through sands and subsoils in the river flow part.

In addition to this, another source for the quaternary alluvial gravel layer serves and the complex aquifer of the conglomerates of the suite "Rrogozhina", in those areas where they contact directly with the quaternary gravel. The water content of the conglomerates is small compared to that of the gravels, but having greater pressure they serve as permanent source for the gravel layer, mainly in the northern part of the layer.

Porosity aquifers with cracks, medium to low water permeability is represented by Middle Pliocene N22rr deposits , sandstones and conglomerates (Rrogozhina formation). Deposits of the Rrogozhina formation come to the surface in the hilly area in the northwest of the city of Rrogozhina. The angle of inclination is 22o–25o and the fall is almost southwestern. The thickness of this formation reaches 250 m.

The waters of this formation are connected with the cracks of sandstones and conglomerates and are mainly infiltration waters that drain deep into the structure as well as in a southerly direction in the erosive section of the structure from the Shkumbin River. Source flows in the range from 0.1 - 0.4 l / s.

The waters of this complex are of practical importance for the supply of drinking water to the population through hydrogeological drilling. They are within the permitted norms for use as drinking water except for those wells where the iron content is above the norm.

Regarding the groundwater level regime of the gravel layer from the made observations, we can say that this regime reflects the fluctuation of the water level of the Shkumbin River, which in turn, depends on atmospheric precipitation.

The main water supply is Rrogozhina Water Supply which uses a flow of Qmin = 10 l / s; Qmax = 15 l / sec and that supplies the city of Rrogozhina. Year of construction 1988. There are three drilled wells. Respectively: well no. 1 with H = 15, Q = 5.5 l / s, well no. 2 with H = 12, Q = 5 l / s, well no. 3 with H = 16, Q = 5 l / s.

Referring to the request of the Municipality of Rrogozhina for increasing the amount of water by 35 l / s due to the reduction of levels in existing wells and its poor quality, referring to the strength of water that fluctuates in values from 24-32 degrees, it is judged that the area where are the current wells and pumping stations of Rrogozhina is not suitable for the required supply in quantity and quality.

On the other hand, after studying the physical-chemical analysis in the existing water supply wells of Rrogozhina, it is concluded that the quality of drinking water is out of standard, referring especially to the general strength.

It is also found that a large number of illegal wells have been carried out in the area of placement of the drinking water stations in Rrogozhina, significantly reducing the level of groundwater and becoming factors of water pollution.

The reduction of the groundwater level has caused the deficiency of the pumps, the water comes out with sand and sludge, as well as the reduction of the amount of water reaching from the projected value 10 l / s to 5 l / s. In the Municipality of Rrogozhina, a detailed reconnaissance of the completed works was carried out - hydrogeological study and drilling in the area of wells and pumping stations of Rrogozhina.

So, the improvement of water supply of the city of Rrogozhina will be done through the opening of wells 1, 2, 3, 4 and 5. Groundwater quality monitoring has been performed by the Municipality of Rrogozhine. Some of the most important parts of the quality analyses are given below.

Groundwater levels of PH varies from 7.49-7-8.7 and are within the allowed norm for drinking water. The total strength of water varies Ws = 25.62-32.76 German degrees , indicators that are far grater than the regulation ones, they are strong groundwater (16-28 German degrees). The norm of drinking water is 10-20 German degrees and the maximum allowed 25 degrees German.

To verify the water quality in these wells it was decided to make an analysis of the water that is currently pumped from the wells that supplies the city of Rrogozhina. The analysis results are listed below.

As it is noticed, this analysis in addition to other parameters shows that the water has a hardness of 28.81 German degrees. The strength of the water is greater than the allowed norm of 20 German degrees, which is the upper limit that must meet the drinking water.

Nr	Parametri	Njësia	Vlera e matur	Metoda Referuese	Standardi Referues
1	Matja e pH	-	7.61	Potenciometri (me pH-metër) P.AGS_SOP-03	EN ISO 10523: 2012
2	Përcjellshmëria elektrike	µS/cm	1027	Konduktometri P.AGS_SOP-04	EN 27888: 1993
3	TC (Karboni organik total)	mg/l	11.72	Spektrometria IK (NDIR) P.AGS_SOP-01	SSH EN 1484: 2000
4	TN (Azoti total)	mg/l	4.64	Kemiluminishenca (CDL) P.AGS_SOP-01	SSH EN 1484: 2000
5	Kloruret, Cl^-	mg/l	52.40	Kromatografi jonike (IC) P.AGS_SOP-02	ISO 10304-1:2007
6	Sulfatet, SO_4^{2-}	mg/l	57.61	Kromatografi jonike (IC) P.AGS_SOP-02	ISO 10304-1:2007
7	Fosfatet, PO_4^{3-}	mg/l	-	Kromatografi jonike (IC) P.AGS_SOP-02	ISO 10304-1:2007
8	Fluoruri, F^-	mg/l	0.56	Kromatografi jonike (IC) P.AGS_SOP-02	ISO 10304-1:2007
9	Nitritet, NO_2^-	mg/l	0	Kromatografi jonike (IC) P.AGS_SOP-02	ISO 10304-1:2007
10	Nitratet, NO_3^-	mg/l	20.62	Kromatografi jonike (IC) P.AGS_SOP-02	ISO 10304-1:2007
11	Amoniumi, NH_4^+	mg/l	0	Kromatografi jonike (IC) P.AGS_SOP-02	EN ISO 14911:2003
12	Natriumi, Na^+	mg/l	42.08	Kromatografi jonike (IC) P.AGS_SOP-02	EN ISO 14911:2003
13	Kaliumi, K^+	mg/l	2.48	Kromatografi jonike (IC) P.AGS_SOP-02	EN ISO 14911:2003
14	Kalciumi, Ca^{2+}	mg/l	70.14	Kromatografi jonike (IC) P.AGS_SOP-02	EN ISO 14911:2003
15	Magnezi, Mg^{2+}	mg/l	82.60	Kromatografi jonike (IC) P.AGS_SOP-02	EN ISO 14911:2003

Figure 5 Water analysis results

This limit is defined in the Decision of the Council of Ministers no. 379, date 25.5.2016 where the regulation for "Quality of drinking water" was approved. This decision transposes the directive 98/83 EC "On the quality of water for human consumption" and approximates the standards of our country with the norms of the European Union.

From the above we conclude that this water must be treated to be softened with a special water treatment plant before taking it to the consumers. The waters of this aquifer are with high general strength, above the standard, 20 German degrees in all cases and in all existing wells, both in the high water period and in the low water period. They also reach 32 German degrees.

The clay cover of the aquifer in this area is relatively small and with poor isolating properties. Surface contaminants can easily penetrate this cover. There are many illegal constructions in the area and as a result there is a lack of sewage and the presence of septic tanks. Analysis show nitrite content in the aquifer.

In recent years, the area has become an area where chemicals are used intensively and as a result the aquifer waters, according to the analysis, have a high content of nitrates.

The cost of operation of the water treatment plant is 12,654,129 ALL per year, which includes maintenance, energy, additional water and salt needed for the technological process. Regarding the impact of the use of drinking water in addition to the health damage, it can cause the reduction of pipe diameters and the reduction of the amortization time of the network.

It has been proven by various studies that the use of hard water is accompanied by a 50% increase from consumption of detergents. This is due to the fact that it is an additional cost for consumers and is calculated within the annual cost having an additional value of 6,772,800 ALL per year for all consumers if we accept a minimum value increase of expenses of 200 ALL per month for each family.

Table 5 Operation cost of water treatment plant

Operation cost of water treatment plant					
					Lek
WTP purchase and instalation					**1,000,000**
Water amount increase	Increasing in %	Water flow l/sec	Cleanig volume m3/year	Water price in lek/m3	**Total lek/year**
	4	1.28	40366.1	48	**1,937,5**
Needed salts usage	Water volume m3/year	Needed salt kg/m3	Salt volume kg/vit	Lek/kg salt	**Total lek/year**
	1009152	0.87084	878811.4	12	**10,545,7**
Additional energy for the WTP	Ore pune ne vit	Average energy consumption in kw/h	Energy price in lek/kw		**Total lek/year**
	8760	1.5	13		**170,**
Additional cost in detergents 50%	Families number	Additional cost lek/month/families	Additional cost lek/year /families		
	2822	200	2400		**6,772,800**
				Total cost lek/year	**19,426,929**
				Total cost euro/year	**141,802.4**

In total, by calculating all the important factors, we will have an total cost of 19,426,929 ALL per year, which will be additional cost to the consumer by increasing the consumer price per m^3/ water.

CHAPTER 5

RESULTS AND DISCUSSIONS

European standards regarding surface water quality, based on the defined criterias, conduct 5 quality classes according to the parameters that these waters must satisfy. Each class summarizes the values of many parameters.

The following is a summary of the characteristics of each class:

Class 1A: It characterizes waters considered untouched by pollution, capable of satisfying the most demanding criterias. Usually these waters are blue.

Class 1B: Of a slightly lower quality, these waters can also satisfy all criterias. Their color is green.

Class 2: The quality of these waters can be considered acceptable for irrigation, industrial uses as well as for the production of drinking water after a very advanced treatment. Drinking for animals is generally allowed. The fish life there is normal, but their reproduction is not always guaranteed. Their color is yellow.

Class 3: The quality of these waters is mediocre; capable of irrigation, cooling and navigation only. In these waters fish life may exist but it may disappear in periods of small inflows and high temperatures. Their color is red.

Out of class: These waters exceed the maximum values allowed in class 3 for one or more parameters. They are considered unsuitable for most uses and may pose a risk to human health and the environment. Their color is black.

By comparing the above parameters with the values given by the standards, it results that Rrogozhina Aquifer water can be classified as a water between classes 1A and 1B. Consequently, we are still dealing with a water which presents minimal treatment requirements. For water of this quality, the recommended water treatment plant would be the one that would contain the basics steps:

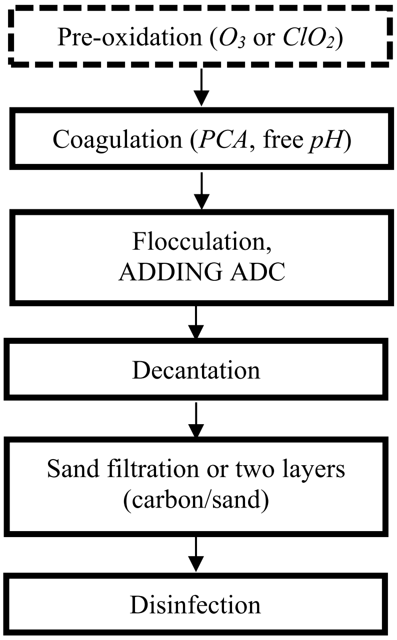
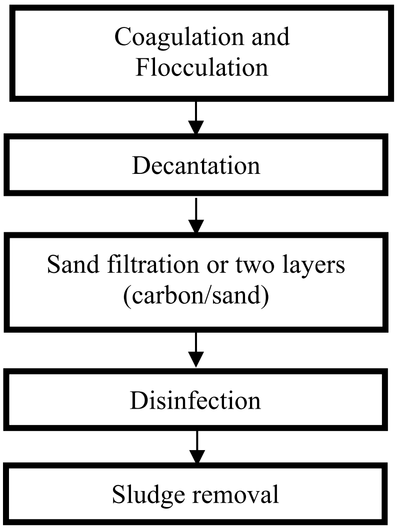


Figure 6 WTP processes for Little contaminated water

The pre-oxidation step (which exists in the plant) has been introduced into dashed lines for two reasons:

Given the perspective of the evolution of aquifer water quality as reservoir water, it would be recomended to use another oxidant, for example chlorine bioxide, to avoid the formation of chlorination products as a result of the use of hypochlorite.

The effect of pre-oxidation on the coagulation-flocculation process is still unknown. It would be necessary to carry out laboratory tests with different oxidants (in current conditions with available oxidants, NaClO and ClO2) to know the effect of the oxidant dose used on the optimal coagulation pH zone. This could be the subject of a subsequent study.



In the figures below are presented the parts of this water treatment plant.

Figure 7 Pumping station

Figure 8 Coagulation-Flocculation Basin

Figure 9 Decantation Area

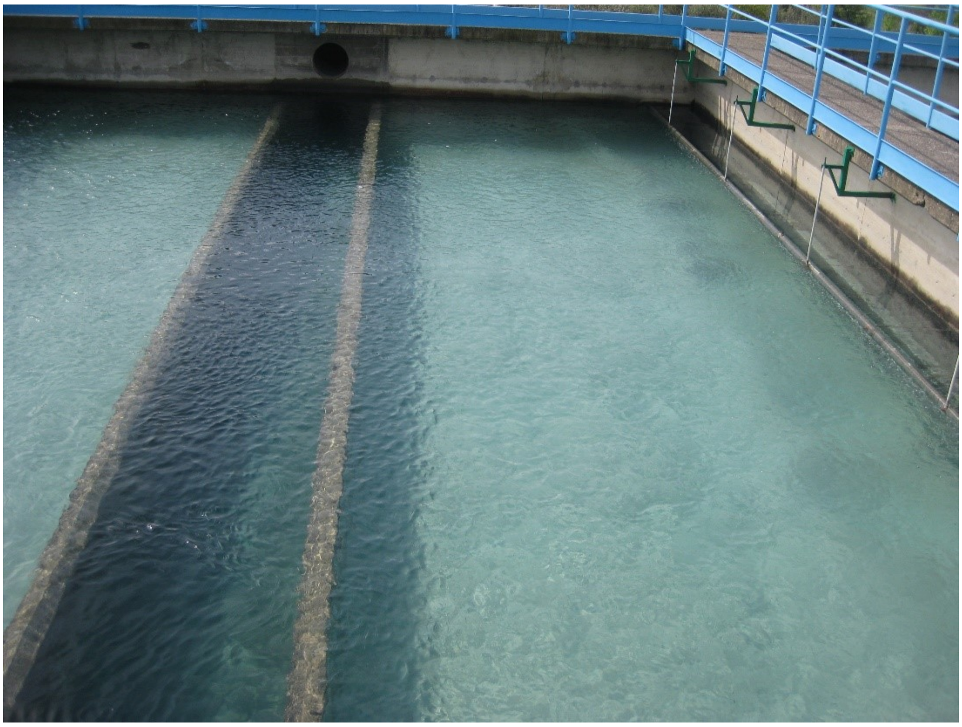


Figure 10 Sand Filters

Figure 11 Sludge removal (exceptional cases, if necessary)

CHAPTER 6

CONCLUSIONS

The cost of operation of the water treatment plant is 12,654,129 ALL per year, which includes maintenance, energy, additional water and salt needed for the technological process. Regarding the impact of the use of drinking water in addition to the health damage, it can cause the reduction of pipe diameters and the reduction of the amortization time of the network.

In the framework of this paper, numerous studies and researches were conducted, both for choosing the right water treatment plant for Rrogozhina Aquifer. Assessing the parameters after each process, it can be concluded that the drinking water production plant in Rrogozhina, meets the norms of the Albanian standard regarding the quality of water produced, as well as organoleptic indicators.

For these parameters, at certain times of the year, alterations can be expected (mainly during the spring and autumn season), a phenomenon that is expected for a reservoir surface water. This is due to the increase of natural nutrients, an increase which is inevitably followed by an increase in the population of phytoplankton and zooplankton.

To avoid problems related to the deterioration of the smell and taste of the water produced, the injection of activated carbon powder at the beginning of the plant is advisable.

The best solution is always to choose the sources with good water quality at the outset to reduce facility and operation costs. But in this case, as the water in the source was not the best quality, the water treatment plant is mandatory.

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