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COMPARING RUSSIAN AND FINNISH STANDARDS OF WATER PURIFICATION

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DESCRIPTION

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Water purification. Comparison of Finnish and Russian standards of water purification.

Abstract

The subject of this thesis is water purification. The first aim of this thesis is to consider different ways of water purification. The second aim is to compare Finnish and Russian standards of water purification. The third one is to show water purification methods on the pattern of Mikkeli water purification plan.
Water purification methods of water intended for human consumption will be described.Combined tables will be done according to the quality requirement of drinking water of both, Finnish and Russian, documents, and will be shown in this thesis. The analysis of this topic will be done effectively and conclusions will be done.
In addition, Mikkeli water purification plant will be described. Common water purification methods of water intended for human consumption will be shown on the pattern of Mikkeli purification plant, special equipment for water purification plant will be shown also and the quality of water in Mikkeli before and after purification will be considered.

Subject headings, (keywords)

Water, water purification, methods of water purification, the quality requirement of drinking water

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CONTENTS

1 INTRODUCTION

Water is the most common natural substance for mankind. It surrounds us in our everyday life almost everywhere. Water is one of the most important things which we need for everyday life. We can't imagine our day without water: we take a shower, wash ourselves, wash dishes, cook, drink, use it for flowers and use it for cars and other everyday activities. Thus, man can't live without water in principle.

However, water is not only the source of our "everyday cases", it has great significance in HVAC – field. Thanks to water we have heating in buildings, so called heating systems; another instance is air conditioning systems which are not the last in our list. At least, it is water supply systems that provide us with water in our taps and other equipment.

There are a lot of examples connected with water that are possible to talk about but in this thesis the main one is potable water. To maintain healthy everyday life we have to drink, that is why the most important aim of water is drinking. Usually men need about 1, 5 – 3 liters of water for everyday life.

Before water comes to our houses, there are a lot of things to do. The source of water supply is chosen and then water is taken from a source, afterwards it is purified according to the standard and after water has been purified by pumps, it goes to the distribution line and to customers.

In this bachelor's thesis it is explained what must be done with water before it goes to purification plant and how water is purified before it comes to customers. The second main question of this thesis is comparison of Russian and Finnish standards and norms of water intended for human consumption and making conclusions about that question.

After introduction comes the description of water supply: what water supply systems are water sources for water supply, common methods of water purification.

Next part is comparison and contrast. After the theoretical part it is time to discuss standards of purification. It is called specification of quality for water purification (for domestic water or water intended to human consumption). It is not a secret that water in Finland is potable from taps. Unfortunately, in Russia it is not so, people can't drink it from taps. It is interesting to know "why", so these two documents are compared, Russian and Finnish, respectively and some conclusions are written.

The last part in this thesis is to apply theoretical knowledge to a water purification plant in Mikkeli and describe it. It is a practical part. Main things about a purification plant are described: what the source of water supply is and what methods for water purification are used in this water purification plant, what equipment is installed and used in this purification plant.

2 WATER PURIFICATION

Before water comes to our houses and we can use it for our purposes, there are a lot of processes. First and foremost, specialists choose the water source. At the same time they estimate environmental conditions, and then choose the system of water supply. After the initial water quality is known specialists select all the necessary equipment for purification and choose required methods for purification. After water is purified and the quality of water is checked and meets the requirements, it comes to the distribution line and to our houses. Every part in this “system” is very important to provide, that is why this chapter starts from the definition of water supply system.

2.1. Water supply system

Various consumers use water in wide range of needs in everyday life. However, the majority of these needs can be divided into three main categories:

1. Consumption for domestic and drinking purposes (drinking, cooking, washing, laundry, cleanliness of dwellings, etc.).
2. Consumption for production needs (consumption by industry, transport, energy, agriculture, etc.)
3. Consumption for firefighting.

Water supply system is a building complex which provides customers with water according to quantity and quality standards respectively. Moreover, water supply system must be safe to supply customers without faults in network and shouldn’t break water quality standards /1, p. 15/.

2.2 Sources of water supply

A source for water supply system should meet a lot of requirements, especially results of topographical, hydrological, hydrogeological, and hydrological and other researches. When we choose a source of water supply system it sets approximately all parts of water supply system. They are water intake, a scheme of water purification plant, and methods of purification and so on. Also it sets the cost of future investments. That’s why a water source is so important to choose/2, p. 8/.

General water sources for water supply can be divided in the following way: a surface source, a ground source, an artificial source.

Surface sources include: seas or parts of sea (bays, straits), channels (rivers, streams, and canals), basins (lakes, ponds, and tanks), natural outlets of groundwater (geysers, springs), glaciers and snowfields. Common characteristics of rivers are high turbidity, high content of organic substances, bacteria and often color. A surface water supply source usually has no constant characteristics because of precipitation. And every month characteristic can be changed because precipitation has different intensity/3/.

Ground sources include: groundwater storage and aquifers. In general ground waters don’t have suspended solids and color because precipitation doesn’t influence ground waters. Artesian waters and spring waters have good sanitary quality. But ground waters are often too highly mineralized and depending on the salt these waters can have unpleasant taste or contain harmful substances /3/.

Artificial sources are used seldom but include industrial desalinated installation which is used, for instance, in Israel or the United Arab Emirates /3/.

A source of water supply should meet the following requirements:

1. Provide obtaining of necessary water quantity for consumers, but also it is necessary to remember that in future water consumption can increase;
2. Provide continuity of water intake to water consumers;
3. Provide the consumers with water at the lowest prices;
4. Save the ecology of nature, where the water source is chosen /1, p. 21/.

2.3 General parameters of water quality

After a source of water supply was chosen, it is necessary to get to know the quality of water. It must be done because there are really a lot of water purification methods and all of them differ. The choice of water purification method depends on the quality and composition of water that is why in this chapter about some general parameters of water quality and some indicators which describe the composition of water will be considered. General parameters of water quality can be divided into three main groups: physical characteristics, chemical characteristics, biological characteristics.

In this chapter each group of water quality characteristics is described in order. In this thesis this kind of information is necessary to know because the main topic is water purification and methods of water purification.

2.3.1Physical characteristics

It should be mentioned that physical characteristics of water are very important for humans, because we can feel and smell odors. According to our organoleptic indicators and sensors, we want water to be clear, colorless and odorless. But of course, it is very difficult to find pure water in water sources because it is full of organic materials and other substances which have influence on physical characteristics of water from a water source. That is why there are some common indicators that describe physical impurities when the analysis is performed. /4, p. 56/.

Physical characteristics of water include:

- **Turbidity**. An indicator of water that shows clarity of water due to the presence of suspended solids in water);
- **Solids**. All impurities of water, except dissolved gases, promote to the solids load. “Solids can be classified by the size and state, by their chemical characteristics, and by their size distribution” /4, p. 57/.
- **Odors**. Odor is usually present in a water source because of the content of decaying organic matter in water. Another reason of odor in water is the reduction of sulfates by bacteria to hydrogen sulfide (H_2S)gas. There are some typical classes of water odors: fishy, ammoniac, decayed flesh, rotten egg, skunk secretion, rotten cabbage, fecal. And of course, every typical odor has a typical chemical formula /4, p. 64/.
- **Temperature**. Temperature is one of the main parameters, because it affects a number of important water quality parameters. The higher temperature of water is, the bigger chemical and biochemical reactions are /4, p. 65/.

- **Color**. The reason of water color comes from dissolved tannins. Many colors connected with water are not “real” colors. They are the result of colloidal suspension /4, p. 65/.

2.3.2 Chemical characteristics

Chemical characteristics are directly connected with physical characteristics and are also very important to know when we are going to purify water. Chemical characteristics often influence organoleptic indicators of water and initial chemical characteristics of water often make it harmful. We cannot see and smell these chemical impurities but they can lead to human diseases. That is why it is necessary to do analysis of water connected with chemical impurities.

In this thesis the following main chemical characteristics are described:

- **pH**. This indicator has great significance because it determines a lot of chemical and biological processes and reactions in water. It is necessary to control this indicator permanently because the change of pH can have bad influence on water purification processes.
- **Hardness**. This indicator shows the sum of calcium and magnesium ions in water. It isn’t harmful for human health.
- **Total residue**. This indicator allows estimating the amount of salts and concentration of impurities which are present in sources of water.
- **Alkalinity**. This indicator is determined by the total amount of hydroxyl ions which are in water and anions of acids. In other words, it is the capacity of water which is needed to neutralize the acid /4, p. 89/.
- **Organic compounds**. Most organic compounds are compositions of different chemical substances like carbon, hydrogen, oxygen and so on. Presence of organic compounds in water can be a cause of bad odor, taste and other factors connected with water. So the concentration of this indicator is measured in a water source/4, p. 94/.
- **Inorganic compounds**. The amount of inorganic compounds in natural water is many times bigger than the amount of organic compounds. It includes nearly the whole periodic table and this analysis is one of the main ones when the quality of water is being determined.

- **Radioactivity**. Many sources of water contain the indicator called radioactivity of some levels. It is not a secret that radioactivity have negative influence on humans, that is why it is necessary to be sure if water is harmless for human health and check this indicator /4, p. 92/.
- **Conductivity**. Water is a good conductor of electricity indeed. “The conductivity of solution is a measure of the ability of that solution to conduct an electrical current”/ 4, p. 91/.

2.3.3 Biological characteristics

Biological impurities are also invisible as well as chemical characteristics. The significance of biological characteristics is quite important for water quality because they are based on the presence of microorganisms in water. Microorganisms are of a great diversity and a lot of them are dangerous for human health. That is why it is necessary to do the analysis of water to be sure that water is harmless before it comes to water consumers. Next indicators are usually checked when water is being purified:

- **Escherichia coli**. In other words E. coli is a bacterium that is commonly a resident of human and animal bowels. It can be also found in water and it is harmful for human health in some amounts /5/.
- **Clostridium perfrigens**. The formal name is C. welchii. It is a bacterium that can be a cause of gas gangrene and other harmful for humans’ diseases /5/.
- **Coliform bacteria**. These bacteria are harmless for humans but the presence of these bacteria helps indicate other pathogenic organisms which can be found in water /5/.
- **Pseudomonas aeruginosa**. One more bacteria which can be a reason of human diseases. It is really stable to antibiotics /5/.
- **Colony count**. The number of bacteria colonies is usually found at the temperature of 22 and 37 degree. This indicator is measured to be sure that water doesn’t have pathogenic bacteria.

2.4. Water purification methods

After a water source is chosen and the analysis of water source is finished, the next step is the selection of the necessary equipment for a water purification plant and methods depending on what contaminant and impurities in water are. The purposes of water purification methods for drinking water can be divided into three main groups: 1. Guaranting the safety of the water and disinfection of water; 2. Improvementof organoleptic characteristics of water; 3. Improvement of chemical characteristics of water /1, p.238/.

Of course, there are a lot of methods and processes of purified water because it is actually purified not only for the sake of human consumption. In this chapter the main methods of water purification for drinking water are described and necessary equipment for each method is considered. Methods which are described in this thesis are the following:

- Clarification and decolouration;
- Disinfection;
- Removal of organic substance, taste and odors;
- Water deironing;
- Water softening.

2.4.1 Clarification and decolouration

Improvement of organoleptic characteristics of water is attained by clarification and decolouration, taste and odor removal of water. Clarification is the removal from water coarse sediment impurities or, in other words, turbidity. Decolouration is the removal from water water-soluble impurities which make water coloured.

Clarification and decolouration may be without coagulation (reagentless clarification and decolouration) and with coagulation. A reagent is a chemical compound (or a coagulant) that makes clarification and decolouraton faster and more intensive.

In practice reagentless method of clarification may be fully done but decolouration may be reached only partially. So that in general to attain the water of drinking quality we use clarification and decolouration with coagulation. A coagulant acts asa catalyst so that dispersed and colloidal particles stick together and get larger. This is the main principle of coagulation.

A lot of techological processes are used for the removal of coagulated impurities after coagulation from water was done. The main ones are sedimentation and filtration.They are carried out by assemblies of tanks and filters respectively. /6, p. 203/.

When choosing necessary equipment for this purification method, everything depends on the initial turbidity and colour of water. If turbidity is less than 120 NTU, it is necessary to use filtration through granular material sand membranes to attain drinking quality water, for example, a sand filter is an appropriate equipment. In other words, it is the so-called single-stage clarification and decolouration.

When turbidity is more than 120 NTU, filtration is not enough. It is the so-called two step-stage clarification and decolouration. The first step is settling. Special equipment for settling is a sedimentation tank. The second step is filtrarion when turbidity is less than 120 NTU.

When turbidity of initial water is more than 1500 NTU before water is going to be purified by two step-stage clarification and decolouration it is preliminary clarificated and decolourated without coagulation with sedimentation tanks and special filters. /6, p. 213/. Some examples are shown on the Figures below.

2.4.2 Disinfection

As it was mentioned before, clarification and decolouration is done by a treatment process called filtration. Filtration is a basic process for clarification, but in spite of removal turbidity, filtration removes particularly some amounts of bacteria. But all of this is not enough to be absolutely sure that water is harmless for human health because there is still a possibility that pathogenic bacteria and viruses are still present in this water./6, p. 269/.

To remove pathogenic bacteria and viruses from water disinfection is used. Disinfection is necessary to be done because bacteria and viruses are invisible but really harmful for mankind and this method makes water safe speaking about biological characteristics.

The type of water disinfection depends on the initial data of water quality. There are a lot of methods, physical or chemical, of water disinfection. To make sure that water is harmless for human health, a strong oxidizer is usually used like a reagent. An example of a strong oxidizer is a chlorine-containing reagent, ozone or chlorine dioxide. It is necessary to remember both chlorine and ozone are dangerous for human health and a residual dose of a reagent must be removed after disinfection was done. To remove a residual reagent from purified water special equipment must be installed. /6, p. 272/.

In addition, oxidizers disinfiction may be accomplished with UV-radiation and membrane technology. The main advantage of using UV-radiation for water disinfection comparing with chemical disinfection is that ozone or chlorine is unsafe for human health in principle. But when using UV-radiation the only thing we need is electricity and no reagents /6, p. 272/.

2.4.3 Removal of organic substance, taste and odors

Taste and odors are characteristics of organoleptic factors. These indicators are basic because no one wants to drink water which has unpleasant odor and taste respectively. There are four common tastes:

1. Salty (the reason is sodium chloride),
2. Bitter (the reason is magnesium sulfate),
3. Sweet (the reasons of this taste are dissolved salts of iron and manganese and calcium sulfate).
4. Acidic (mineral water is usually acidic)

In addition to that the presence of organic compounds in water can be a cause of unpleasant water taste. As a result of the subsequent chemical reactions, odor and taste can be changed. Odors are divided into two groups. They can be natural origin odors and artificial origin odors.

The removal of organic substance, taste and odors depends on nature origin and can be performed by oxidation (for example, chlorine and ozone) or by sorption. In some cases removal must be performed both by oxidation and sorption.

As it was mentioned in the previous chapter about disinfection, oxidation is not totally safe for human health and some special operations must be performed to delete a residual reagent. That is why sorption is preferred.

Sorption is reliable comparison with oxidation because the basis of this method is the extraction from water organic compounds. As for oxidation it is all the chemical reactions and transformation of compounds that can lead to formation of new ones. /6, p. 279/.

The most common sorbent is activated carbon. Activated carbon is usually used asa filter load. So a filter where activated carbon acts as a filter load is called a sorption filter. This is the special equipment that removes organic substance, taste and odors. Water comes through a filter and organic substances stay on the load because activated carbon acts as a trap. /6, p. 282/.

2.4.4 Water deironing

Ground waters are often characterized by high amount of iron. High amount of iron makes water coloured, adds to water metallic taste and becomes a cause of corrosion. In addition, high amount of iron isn't safe for human health. That is why water with high amount of iron must be deironed /5, p. 302/.

There are a lot of methods called “deironing”, but two main ones are reagents and reagentless. Nowadays a reagentless method is both aeration and filtration. Reagents methods are oxidation, filtration, flotation, settling and electrocoagulation or combined methods. /5, p. 305/.

Reagentless method is usually used when pH of initial water is less than 6,7 and alkalinity is less than 1 ml-eq/l. Aeration is the process when air bubbles come through water. Aeration is usually used when oxygen saturation is necessary for the oxidation of substances such as iron/6, p. 305/. When both aeration and filtration are used, iron sorts out and stays on a filter load. An iron film is formalized on a filter load and it is a catalyst of deironing. /6, p. 308/.

Reagents methods are usually used when pH of water is poor and oxidation is high. The most common process for this method is flotation. Flotation is the process of separation of small solid particles (iron in our case). Special equipment for this process is flottatore. Usually it passes in 4 steps:

1. Oxidation of iron,
2. Dissolution of the air in water and formation of bubbles,
3. Formation of a complex compound the so-called “air bubble with iron hydroxide”,
4. Levitation of this complex compound /6, p. 313/.

As it was mentioned above in any case when reagents methods are used the first step is oxidation and the second one is filtration, or flotation, or settling. This method is usually used when the source of water supply is ground water. The choice of process depends on the initial amount of iron in water.

2.4.5 Water softening

Water softening means removal of calcium and magnesium cationes from water. Water softening is usually performed in following ways: a thermal process; a reagents process (alkalization); ions exchange; a combined method which includes different variation of processes which are shown above/6, p. 364/.

The choice of process depends on the quality of water and necessity of how deep water should be softed. Speaking about ground waters ions exchange is the best one. Ion exchange is the process when water is filtrated though special media. Special media includes Na^+ and H^+ ions which exchange places with ions Ca^+ and Mg^+ which are in the water we are going to turn into soft. The equipment is filters with special media. It is deep softening /6, p. 364/.

Touching upon the item of surface water alkalization is the case when it is also necessary to clarify the water. Lime is added to water before filtration or settling and hardness is reduced. This process it the best one, when it is necessary to reduce hardness not in big amounts. And it is usually applied/6, p. 365/.

Speaking about a thermal process it is not usually used for purification of water intended for human consumption. But this method is easy to bring into practice. The idea of this method is heating water till the temperature of 100 degrees and after all the water becomes soft /6, p. 364/.

3 SPECIFICATION OF QUALITY FOR WATER PURIFICATION

There are a lot of impurities in water indeed. Most of them were described in Chapter 2, water purification. Before water is purified there are several processes to be done. Each source of water supply has its own composition. It is defined by a specific chemical analysis in laboratories and usually is called “initial data”. It is necessary to know the initial data of a water supply source to find the equipment for correct purification. But it is not enough to know only initial data of a water supply source. It is necessary to know the quality of water that should be obtained at the end of purification.

All the countries have the document that regulates the quality of water after it has already been purified and came to consumption. In Finland the main document is “Decree of the Ministry of Social Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (461/2000)”/7/ and in Russia it is “Sanitary-hygienic rules and norms SanPin 2.1.4.1074-01 “Potable water. Hygienic requirements for water quality for centralized drinking water supply systems”./8/

In this chapter, firstly, Finnish and Russian documents are described separately and, secondly, they combined into common tables and at the end compare both of them, analyzed and identified the differences.

3.1 Finnish norms on the quality of drinking water

As it was mentioned before the name of Finnish document is “Decree of the Ministry of Social Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (461/2000)”/7/. First, it is written some general things from this document. It is divided it into two main chapters. They are the quality requirement and the monitoring programme and each part in order of appearance is described.

3.1.1 The quality requirement

According to "Decree of the Ministry of Social Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (461/2000)" drinking water should be free of micro-organisms and parasites, it shouldn't contain substances which can have hazard influence on humans/7, p. 2/.Water which is going to be used for human consumption should not be a reason of corrosion in pipes and should not be a cause of problems with water-using devices /7, p. 2/.

The water quality which is purified for human consumption should meet quality recommendations from "Decree of the Ministry of Social Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (461/2000)"/7, p 2/.

Reduction of water quality is possible. It can be allowed from complying with values which are shown in Decree, Annex I, Table 2. The person who wants to reduce the water quality intended for human consumption should write the request with the necessary information (reasons, parameters of water, number of customers, area etc) to The Provincial State Office/7, p. 2/. The decision about permission or prohibition of quality reduction is made by the municipal health protection authority and another relevant authorities /7, p. 3/.

3.1.2The monitoring programme

The regular monitoring programme of water quality is necessary to be done. Minimum number of samples for monitoring is shown in Annex II, Degree /7, p 3/. The programme consists of check monitoring and audit monitoring.

Check monitoring is done to get regular common information of organoleptic and microbiological composition of water. Also it is done to know how effectively purification is, especially disinfection. The purpose of audit monitoring is making sure that water meets the requirements of Annex I, Degree /7, p. 3/.

The municipal health protection authority should set up an individual monitoring programme with each provider of water for human consumption. Besides, the requirements of Degree, all initial data of water and area local conditions should be taken into account when implementing the monitoring programme. Because of changeable conditions the programme should be examined at least with the interval of five years and, generally, when it is necessary. /7, p. 4/.

Water should be examined with regular monitoring. The quantity of samples for monitoring is shown in the Annex II, Degree. The methods of water analyses which are used in the monitoring programme should be the answer with SFS-EN standards or with ISO standards or should meet the precision of Degree requirements/7, p.4-5/.

If purified water after the monitoring programme and after a repeated case doesn't meet microbiological standards of Degree (Annexes I and IA, Table 1), or if in purified water detected parasites which can have hazard influence on human health were detected, the municipal health protection authority and a water provider should scan the cause and repair the situation. Meanwhile, the consumers at once have instructions how to guard a disease which can occur /7, p. 5/.

If the excess of parameters which define the water quality is negligible in accordance with municipal health authority and Provincial State Office, water derogation is permitted. /7, p. 5/.

3.2 Russian norms on the quality of drinking water

As it was mentioned at the beginning of this chapter the name of the Russian document is “Sanitary-hygienic rules and norms SanPin 2.1.4.1074-01 “Potable water. Hygienic requirements for water quality for centralized drinking water supply systems”/8/. Usually it is called SanPin.

Firstly, one common thing from this document is described. It is divided it in two main chapters. They are the quality requirement and the monitoring programme and each part respectively is described.

3.2.1 The quality requirement

According to “Sanitary-hygienic rules and norms SanPin 2.1.4.1074-01 “Potable water. Hygienic requirements for water quality for centralized drinking water supply systems”(further is SanPin) quality of drinking water should be safe in the epidemic and radiation factors, it also should be harmless in the chemical composition and have favourable organoleptic properties. The safety of the drinking water in epidemic aspects is defined with standards of micro-organisms and parasitological indicators which are shown in Table 1, SanPin /8/.

Favourable organoleptic properties should meet the requirements of Table 4, and also the requirements of Table 2, Table 3, Appendix 2, SanPin, which can have influence on organoleptic properties. The presence of some visible organisms in water is forbidden. The surface film in water is also forbidden. The safety of the drinking water in radiation factors is defined with Table 5, SanPin /8/.

Reduction of water quality is possible. It can be allowed from complying with values which are shown in Table 2 and Table 4, SanPin. New values of water composition should be complied with the chief state sanitary doctor of the respective area only. Reduction can only be done on the basis of estimation of every Russian area condition separately and in accordance with the applied technology of water purification /8/.

3.2.2 The monitoring programme

According to the law of Russia “About Sanitary and Epidemiological population wellbeing” the monitoring programme is necessary to be done. The monitoring programme is done by a provider of water intended for human consumption. /8/.

In accordance with Appendix I, SanPin, each provider of water for human consumption sets up an individual monitoring programme. Besides the requirements of SanPin, all initial data of water and local conditions of area should be taken into account when the monitoring programme is being performed. The monitoring programme is coordinated by municipal health authority /8/.

A provider, who is responsible for the operation of water supply systems, permanently accomplishes the monitoring programme in the places of water intake, before the distribution system and in points of the external and internal water supply network /8/.

The quantity and frequency of water samples is defined with Table 6, SanPin. Types of defined indicators when monitoring programme is done are shown in Table 7, SanPin. When checking the quality of water in distribution networks it is defined with microbiological and organoleptic indicators. It is shown in Table 8, SanPin/8/.

The deviation from hygienic regulations can be possible only in accordance with municipal health authority and legislation of Russia. In case of water degradation municipal health protection authority and a water provider should find the cause and resolve it. A provider should write a planned schedule how to solve the problem and coordinate it with the municipal health authority. Meanwhile, the consumers at once have instructions how to act /8/.

3.3 Comparison

Firstly, quality recommendations of Finnish and Russian standards are integrated and a further monitoring programme too. The results are shown in the tables below.

3.3.1 Comparison of quality recommendation

Here are the tables. The first is a combined Finnish and Russian chemical standard (maximum possible concentrations). The table in on the next page.

Table 1. Chemical standards for water intended for human consumption in Finland and Russia respectively /7 and 8/

№	Chemical standards (maximum possible concentrations)	Units	Finland	Russia
1	Acrylamide	mg/l	0,0001	0,01
2	Aluminium	"	0,2	0,5
3	Ammonium (NH 4)	"	0,5	0,5
4	Ammonium (NH 4 - N)	"	0,4	-
5	Antimony	"	0,005	0,05
6	Arsenic	"	0,01	0,05
7	Barium	"	-	0,1
8	Benzene	"	0,001	0,01
9	Bentso(a)pyrene	"	0,00001	0,005
10	Beryllium	"	-	0,002
11	Boron	"	1,0	0,5
12	Bromate	"	0,01	-
13	Cadmium	"	0,005	0,001
14	Chlorophenols, total	"	0,1	0,25
15	Chromium	"	0,05	0,05
16	Chromium (residual free)	"	-	0,05
17	Chromium (residual binding)	"	-	1,2
18	Copper	"	2,0	1,0
19	Cyanide	"	0,05	0,035
20	1,2-dichloroethane	"	0,003	0,2
21	Epichlorohydrin	"	0,0001	0,01
22	Fluoride	"	1,5	1,5
23	Formaldehyde	"	-	0,05
24	Iron	"	0,2	0,3
25	Lead	"	0,01	0,03
26	Marganese	"	0,05	0,1
27	Mercury	"	0,001	0,0005
28	Molybdenum	"	-	0,25
29	Nickel	"	0,002	0,1
30	Nitrate	"	50,0	45,0
31	Nitrate nitrogen	"	11,0	-
32	Nitrite	"	0,5	3
33	Nitrite nitrogen	"	0,15	0,1
34	Ozone, residual	"	-	0,3
35	Pesticides	"	0,0001	0,002
36	Pesticides, total	"	0,0005	0,002
37	Polyacrylamide	"	-	2,0
38	Polyphosphate	"	-	3,5
39	Polycyclic aromatic hydrocarbons	"	0,0001	0,015
40	Selen	"	0,01	0,01
41	Silicic acid, activated	"	-	10
42	Strontium	"	-	7,0
43	Sulphate	"	250	500
44	Sodium	"	200	200
45	Tetrachloroethene and Trichloroethene, sum	"	0,01	0,05
46	Trihalomethanes, total	"	0,1	0,2
47	Vinyl chloride	"	0,0005	0,05
48	Zinc	"	-	5,0

The second one is a combined Finnish and Russian microbiological standard (maximum possible density).

Table 2. Microbiological standards for water intended for human consumption in Finland and Russia respectively /7 and 8/

Microbiological standards (maximum density)	Unit	Finland	Russia
Escherichia coli	cfu/100ml	0	0
Enterococci	cfu/100ml	0	-
Pseudomonas aeruginosa	cfu/250ml	0	-
Colony count (22 °C)	cfu/ml	100	-
Colony count (37 °C)	cfu/ml	20	50
Gardia Lamblia Cyst	cysts number/50l	-	0
Clostridium perfringens (including spores)	cfu/ml	0	0
Coliphage	FFU/100ml	-	0
Coliform bacteria	cfu/250ml	0	-

The third is a combined Finnish and Russian quality recommendations for indicator parameters, including organoleptic indicators (maximum target values for indicator parameters). The mark "-" means that country, Finland or Russia, doesn't check this parameter.

Table 3. The quality recommendations for water intended for human consumption in Finland and Russia respectively /7 and 8/

Indicator (maximumconsentration)	Units	Finland	Russia
pH	pH-units	6,5-9,5	6-9
Conductivity	µS/cm	2500	2000
Oxidizability	mg/l	5,0	5,0
Hardness	mg-e/l	-	7,0
Surfactants, anionic	mg/l	-	0,5
Turbidity	mg/l	1	1,5
Colour	color degree	1	20
Odour and taste	grade	1	2
Total organic carbon	mg/l	no abnormal change	0,1

The last one in this chapter is a combined Finnish and Russian quality recommendations for radioactivity (maximum target values for indicator parameters).

Table 4. The quality recommendations of radioactivity for water intended for human Finland and Russia respectively /7 and 8/

Radioactivity	Unit	Finland	Russia
Total alpha-radioactivity	Bq/l	-	0,1
Total betta-radioactivity	"	-	0,1
Tritium	"	100	-
Total indicative dose	mSv/year	0,10	-

3.3.2 Comparison of monitoring programmes

Due to the chapters about water monitoring is totally different in Degree and SanPin, so it is impossible to draw up some combined tables. It is very complicated to compare this part, so that before comparison is started, some definitions and notes are written.

Point of compliance is the point where a water sample for monitoring is taken.

Point of compliance in Finland: The requirements of Degree are for the water that is taken from the consumer’s tap to the water which is from the tank before distribution network. The provider of drinking water is responsible for making sure that the quality requirements of water are applied up to the connecting point to the premises' pipework /7, p.2/.

Point of compliance in Russia: There are three main points of compliance: places of water intake, before the distribution network and in points of the external and internal water supply network /8/.

Table 5 is a combined table, which shows minimum parameters which should be checked before water comes to customers, “+” means it is usually checked and “-” it is not.

Table 5. A combined table of monitoring parameters of Finland and Russia respectively /7 and 8/

Check monitoring (at least the following parameters)	**Finland**	**Russia**
Odour	+	+
Taste	+	+
Turbidity	+	+
Colour	+	+
pH	+	+
Conductivity	+	+
Iron	+	+
Manganese	+	+
Nitrite	+	+
Aluninium	+	-
Ammonium	+	+
Clostridium perfringens	+	+
Coliform bacteria	+	-
Colony count 22°C	+	-
Colony count 37°C	+	+
Pseudomonas aeruginosa	+	-
Coliphage	-	+
Escherichia coli	+	+
Gardia Lamblia Cyst	-	+
Sulphate	-	+
Chloride	-	+

As it was mentioned before chapters about water monitoring are totally different in Finland and Russia, but here is an attempt to approximate them to each other.

It is necessary to say about **daily volume of water per capita** in Finland and Russia. It Finland it is 200 liters per capita and in Russia is 250 liters per capita. According to Table 2, Annex II, Degree, the number of consumers can be used in a table instead of the volume of water a day, so the volume of water is converted in consumers, because in Russia only consumers are used as an indicator /7 and 8/.

The table you can see below is the Finnish minimum frequency of analysis of water intended for human consumption for regular monitoring.

Table 6. Finnish requirements for the regular monitoring programme /7, Annex II/

Number of consumers	Check monitoring	Audit monitoring
	Minimum number of samples per year	
50 - 250	1	1 at 2 years interval
250 - 2500	4	1
500 - 1000	6	1
2500 - 50000	6 - 32	1- 4
50000 -100000	32 - 64	4
100000 - 150000	64 - 94	4 - 6
150000 - 300000	94 - 184	6 - 9
300000 - 500000	184 - 304	9 - 12
>500000	304 + additional samples/delivers 1000 m3/d	additional samples/delivers 25000 m3/d

Monitoring of water in accordance with Russian rules is shown in Table 7, Table 8 and Table 9.

Table 7. Russian requirements for the regular monitoring programme in points of the external and internal water supply network /8/

Number of consumers	Minimum number of samples per month
< 10000	2
10000-20000	10
20000-50000	30
50000 -100000	100
>100000	100 + one additional sample for every 5000 of population

Table 8. Russian requirements for the regular monitoring programme before water comes to the distribution line /8/

Type of indicator	Minimum number of samples per year				
	for ground source			for surface source	
	Number of consumers				
	< 20 000	20000-100000	> 100000	< 100 000	> 100000
Microbiological	50	150	365	365	365
Parasitologic	isn't done			12	12
Common indicators	4	6	12	12	24
Chemical compounds	1	1	1	4	12
Radioactivity	1	1	1	1	1

Table 9. Russian requirements for the regular monitoring programme in places of water intake /8/

Type of indicator	Minimum number of samples for one year	
	For ground source	For sufrase source
Microbiological	4(every season)	12(every mounth)
Chemical compounds	4(every season)	12(every mounth)
Radioactivity	1	1

3.4 Conclusions on comparison

After both Finnish and Russian documents were described, they were found totally different but the goal of this thesis was to find similarities and differences and compare them. Two similar parts of these documents were found out; they are quality recommendations and a monitoring programme. Firstly, conclusions about quality recommendations are written and then about a monitoring programme too.

3.4.1 Conclusions on quality recommendations

Four combined tables about quality recommendations were done where every person who is not versed in chemistry can come to obvious conclusions. If we take a look at Table 1, Chemical standards, it is a must to say that in Finland the water purification technology is implemented effective than in Russia because nearly all chemical parameters in Finland are in 10-100 times less than it Russia.

Speaking about Table 2, Microbiological standards, there are different parameters in Finland and Russia. In Finland these parameters are wider, but in Russia, for example, some parasitic parameters are included (for example Gardia Lamblia Cyst) but for similar ones the requirements are the same. Almost all of these parameters are responsible for water to be clear of harmful bacteria dangerous for human health and both Finland and Russia are quite good at this part.

Table 3 shows combined Finnish and Russian quality recommendations for indicator parameters, including organoleptic indicators. These parameters have great significance indeed because they answer for organoleptic indicators (taste, odor and so on). It is obvious from this table that in Finland purification is totally different from Russia according to these parameters. It is much more effective.

Looking at Table 4, the quality recommendations of radioactivity for water intended for human Finland and Russia, it is difficult to draw up conclusions on this table, because indicators are different, all is possible to say both countries check radioactivity parameters.

The main conclusion of this chapter is that water purification in Finland is much more effective in all respects: chemical and microbiological, organoleptic and other parameters of water. That’s why in Finland water is potable from a tap but in Russia it is not. In Russia authorities should change SanPin and all equipment of water purification plants completely to make sure that people can drink water from a tap. But it is not so easy; it is not economical, because Russia is many times bigger than Finland.

In Russia there is another SanPin 214.1116-02 for drinking water that is purified for sales in bottles, for example, it is close to the Finnish standard which is described in this thesis. But the of this thesis goal was to compare water which goes to a distribution line and goes from taps of consumers. It would be fair to say Finland standards are better than Russian indeed.

3.4.2 Conclusions on the monitoring programme

Considering the monitoring programme in Finland and Russia as it was mentioned before was difficult to draw up combined tables like in the quality recommendations. But one was made on parameters which are necessary to be checked. Looking at Table 5, it should be said that checked parameters are the same in both countries with the exception of some values. So, both countries look after to be sure about water quality.

Comparing Table 6, the Finnish standard and Table 7-9, the Russian standard, we can see that the minimum number of samples is totally different. In Russia checking of water quality in all tables is done more frequently than in Finland. It is due to the quality of water since purification in Finland is much better than in Russia and if the reduction of water quality exists, in Finland it is easier to resolve this problem because some deviations are possible, water can be used after reduction, for example, not for drinking but for other purposes (washing, cooking, etc.). As for Russia it is harder because the quality recommendations for purification are not so strict and if reduction exists, it can be more dangerous than in Finland. That’s why in Russia according to researches which was made for this thesis it is necessary to take samples more frequently than in Finland.

The structure of analyzed documents is similar to each other, but to the most extent parameters are totally different. The Finnish standard is safer for human health than Russian and it permits to drink water from a tap in Finland.

4 MIKKELI WATER PURIFICATION PLANT

The last part in this thesis is the excursion to water purification plant in Mikkeli. It is the so-called practical part where all the theoretic knowledge, which was gotten at university in Saint-Petersburg and here in Mikkeli while theoretical chapter of this thesis was being written, is applied. In this chapter the main points about a water purification plant in Mikkeli are described and in an organized manner about this plant applying all theoretical knowledge.

4.1 General information

There are three water purification plants in Mikkeli. The excursion was to the plant called “Pursiala waterworks”. Sources of water supply are ground water and an artificial storage. Water is pumped from wells and then goes to the purification plant. The total water volume flown per day is 6500 cubic meters. You can see in the table below the initial data of water source used in this purification plant:

Table 10. The initial data of water source from first well /9/

Indicator	Value
Conductivity	34,8
Fe	17,47
Mn	1,04
Cloride	36,5
pH	6,5
NH_4	0,1
NO_3	0,5
NO_2	0,01
Temperature	7,5
Coliform bacteria	0

Water which was purified and comes to customers is shown in the table above. It is a combined table where it is obvious that purified water meets Finnish water quality requirements. The first column shows indicators of purified water and the second one – Finnish requirements for water intended for human consumption:

Table 11. A combined table: comparison of purified water according to Finnish requirements /9/

Indicator	Value	Finnish requirements
Conductivity	30	2500
Fe	0,07	0,2
Mn	0,01	0,5
Cloride	23,5	250
pH	8,3	6,5-9,5
NH4	0,01	0,5
NO3	<0,5	0,5
NO2	0,01	50
Temperature	8,5	no value in document
Coliform bacteria	0	0

4.2 The scheme of Mikkeli water purification plant

The figure you can see below is a scheme of Pursiala water purification plant. Here you can see the main information about methods and reagents that are used at this purification plant. The system is gravity.

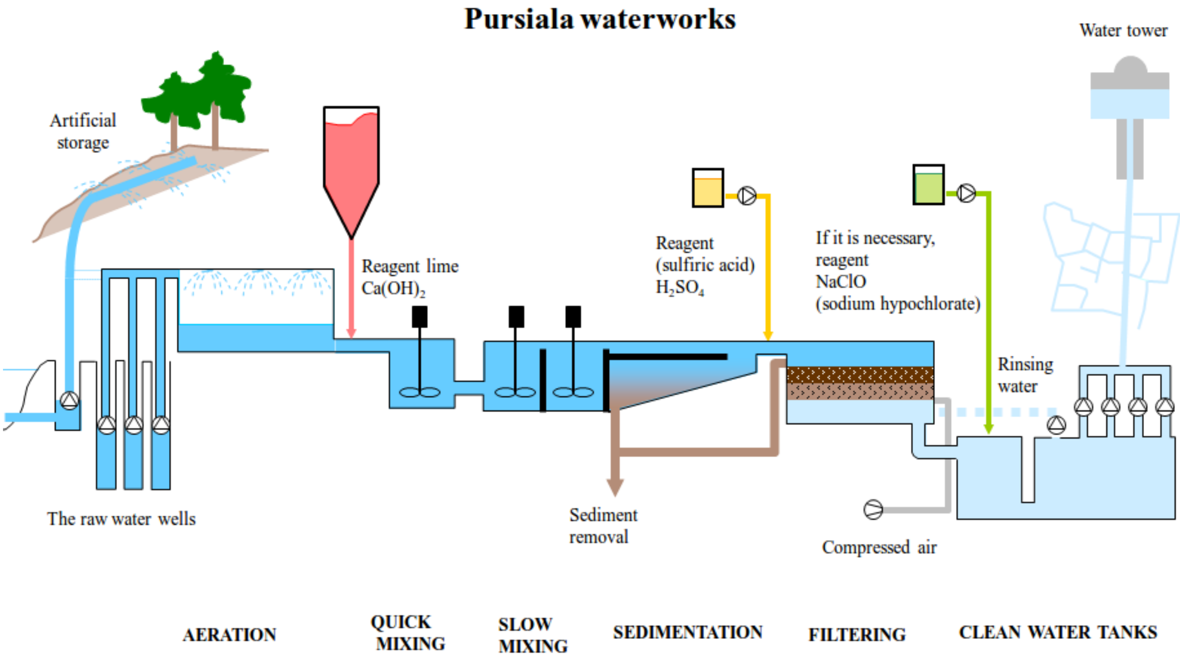

Figure 1. Scheme of Pursiala water purification plant /9/

4.3. The description of the water purification plant

In this Chapter the water purification plant according to the scheme and data which was received on the excursion is described. On the Figure 2 below you can see the source of water. It is a wellspring which flows on the ground and then has leaked throughthe ground for 200 days before getting in the well.Wells are shown in Figure 3 and 4.

Figure 2. A water source

Figure 3. Wells

Figure 4. Inside a well

Water from wells is pumped to the water purification plant to the room where aeration occurs. Aeration is shown on the Figure 5. Aeration is necessary for reducing of CO_2 before the next step of purification.

Figure 5. Aeration

After water was aerated the next step is adding lime to water and contacting it with a reagent. The contacting usually goes in two phases. They are mixed: quickly and slowly. Water reacts with lime it is the so-called alkalization and after all it is ready for sedimentation.

Alkalization makes water more prepared for the futher method of treatment called settling. Slow mixing and settling are shown on figures below. Slow mixing was difficult to capture because all the processes are invisible to our eyes but if take a closer look at it is possible to see a blade (only one on Figure 7, in general they are 4 or 5) due to which slow mixing is performed. There are 2 old ones and 2 new settling tanks on this purification plant.

Figure 6. Adding lime (a reagent) and quick mixing

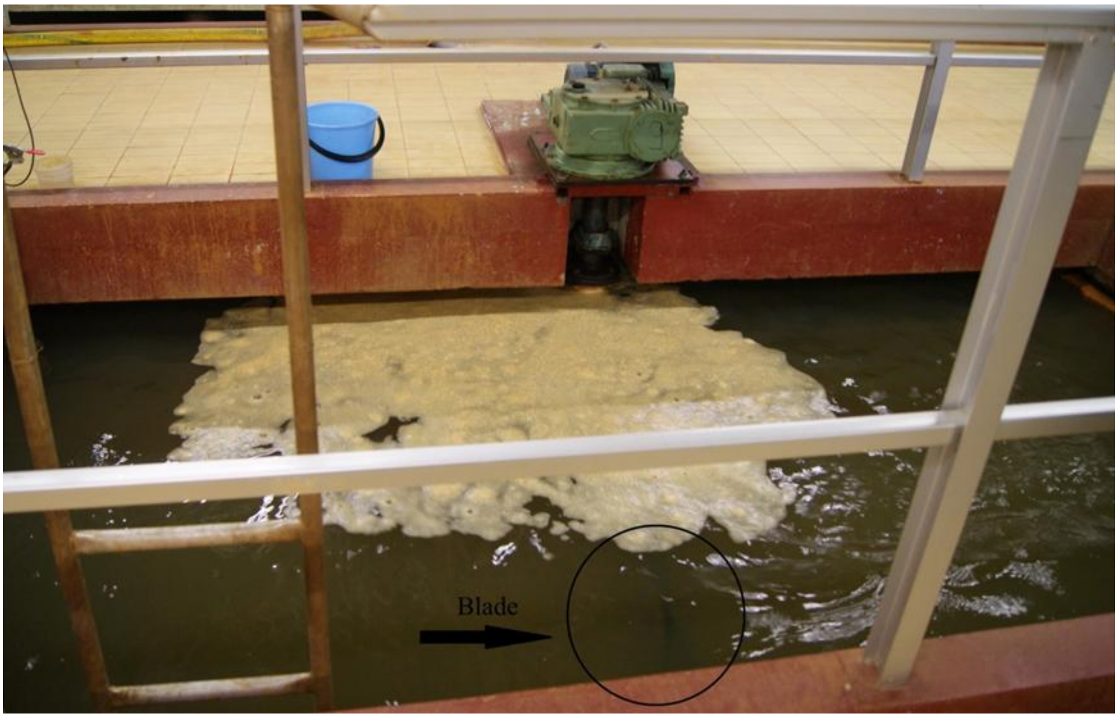

Figure 7. Slowwater mixing with lime before water has settled

Figure 8. Water settling

After water reacts with lime it goes to a settling tank and settles there. The settling tank is shown on Figure 8. Prior to the next step of purification, a new reagent is added. It is sulfuric acid the so-called reagent for the coagulation process. The next method of purification is clarification and and decolouration. The process is filtration.

The equipment which is necessary for filtration is a sand filter. There are 5 new and 4 old sand filters at this water purification plant. They are shown on the Figure 8.

Figure 8. Sand filters

Water comes thougth filter media and suspended heavy solids and some chemical compounds stay too long on media. After filtration was performed water comes to clean water tanks. In theory, after water was filtrated, the method of disinfection should be applied and it is shown on Figure 1. But talking about this case in practice it is not necessary because according to initial data of water the indicator coliform bacteria is zero. These bacteria are an important indicator touching upon harmfull characteristics and if it is zero there is no sense to pay for a disinfection method.

The last part defines how water comes to customers. Clean water tanks which recieve purified water after filtration are situated under the ground. The area of water tanks is shown on Figure 9 and a manhole of a water tank on Figure 10. As it was mentioned above there are three water purification plants in Mikkeli and after water was pufiried it is mixed in a distribution line and comes to customers.

Figure 9. The area of clean water tanks (situated underground)

Figure 10. Manhole clean water tanks (situated underground)

A distribution line is shown below in Figure 11. Water from clean water tanks by pipes comes to a machine room and then it is pumped to the distribution line. The scheme graphically shows how this system works.

Figure 11. An engine room (a distribution line and a pump are shown)

Managing of this station is completely controlled from the office where all Mikkeli waterworks are handled. A dispatching office is shown on the Figure 12.

Figure 12. A dispatching office

It is necesarry to remember that after water is mixed with purified water from other purification plants in a distribution line some amount of water comes to a water tower. It is very important to say about points of compliance because it is necessary to make sure about water quality.

Points of compliance in of Pursiala water purification plant are: in wells; after settling tanks; in clean water tanks after filteration; in a distribution line and before it comes to a water tower. All results about these points are stored in the archive and done permanently.

4.4 Resume about the water purification plant

Pursiala water purification plant is a modern system of water purification. At this plant are used common methods and in total purified water meets the requimenets of Finnish standards.

Processes in order are shortly following: aeration; mixing; settling; filtration.Methods in order are following: clarification and decolouration (witha coagulant); disinfection (if it is necessary);organic substance, taste and odors removal.

All the equipment works automatically which helps to economize time. When it is necessary filters and settling tanks are washed automatically.It is shown in Figure 1. It is done not to reduce the quality of purified water because all the equipment actually has an expiration date.

5 CONCLUSION

The main topic of this thesis was water purification. This topic is large, because usually water is purified for different purposes; talking about purposes the main are water purification for domestic and drinking purposes and for production needs. It this thesis drinking water purification was described.

The main topic was subdivided into some questions. The first question was theoretical part. In this part was explained what is necessary to be done with water before it goes to a purification plant and how water is purified before it comes to customers step by step: first the source of water supply is chosen, then water is taken from a source, afterwards it is purified according to the standard and after water has been purified, it goes to the distribution line by pumps and to customers. Talking about methods of water purification due to researches of this thesis, all the necessary methods for purification of water intended for human consumption were chosen and described.

When water is purified it is necessary to purify it according to special document. This document is called specification of quality for water purification and describes the quality of water which it necessary to get after water was purified. Every country has such kind of document and different norms and rules for water purification. So the second main question of this thesis was comparison of Russian and Finnish standards and norms of water intended to human consumption and making conclusions on that question. Both documents Russian and Finnish has the same structures, they are divided in two main parts: quality recommendations and monitoring programme. As for quality recommendations the main conclusion is that Finnish norms are stricter than in Russia and this is the main reason why water in Finland is potable from tap. Talking about monitoring programmes in both countries they are totally close to each other and done regularly.

The last question in this thesis was excursion to Mikkeli water purification plant. The goal was to apply theoretical knowledge to a water purification plant in Mikkeli called Pursiala and describe it. Some general things were considered, described the scheme and methods which are used on this water purification plant. The main conclusion of this question is that Pursiala water purification plant is a modern system of water purification. It is fully automated plant. All the equipment works automatically which helps to economize time. At this plant common methods for water purification intended for human consumption are used and in total purified water meets the requimenets of Finnish standards.

At the end it is safe to say that water purification is complex prosses which requires a lot of steps and knowlenge indeed. All main steps were described in this thesis and all common information about water purification was considered.

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