Industrial and Storm Water Treatment and Recirculation Reuse in Feni Industry - Kavadarci

Petko Pelivanoski[1], Zivko Veljanoski[1], Goce Taseski[1], Aleksandar Maletik[2]

[1]University of Ss Cyril and Methodius, Faculty of Civil Engineering; Department of Water Supply, Sewerage, Treatment and Irrigation, 1000 Skopje, Macedonia,

[2] Graduate engineer, technologist.

Abstract

The appearance of longer droughts; intensive population growth in the arid areas; as well as continued scarcity of quality water are problems, which occur more frequently lately. Therefore, the idea of finding a new reliable alternative water source is considered.

Reuse of industrial wastewater is an important strategy for reducing freshwater consumption and wastewater generation. From an economic perspective, industrial wastewater reuse reduces the costs of fresh water supply and wastewater disposal. Many industrial users of fresh water are under increasing pressure to reuse water within their facilities. Their goal is to minimize the amount of fresh water use and waste water that is discharged to a receiving stream.

The paper presents a method of industrial and storm waste water treatment from the ferro-nickel production of "Feni Industries" - Kavadarci and its recirculation water reuse in the technological process either. This way the both dual economic and environmental benefits are achieved. First, with the industrial waste water treatment and its recirculation reuse significantly is reduced the use of fresh water. Second, more fresh water remains to the agriculture. And the last but not the least, by reducing the amount of waste water that is being discharged into recipient, an environmental benefit is achieved.

Keywords: Industrial waste water treatment, storm water, recirculation, reuse, economical and environmental benefits.

1. Introduction

Factory, producing Ferronickel, is located near Kavadarci, east of the meridians of 21,94º and north of the equator at 31,43º. The Feni Industries started with production in 1981. Since the last restart of the production in 2001, conditions over environmental impact of industrial processes. are gradually improving. Meaning, permanent improvement of technology production and use of materials that reduce harmful emissions of pollution through air and water.

Significant harmful emissions of the Feni Industries are air pollution and pollution of surface and groundwater by discharging non purified water in the recipients.

Treatment of the waste water and reducing the quantity of technological waste water, discharged in the foreign recipients (Through the South Channel to Black River) are necessary actions in order to make protection of surface waters from the harmful emissions of the Feni Industries. Therefore, economically and environmentally, the realization of the recirculation system in terms of providing the technological process with raw water is the most rational option.

This paper provides technological flow chart of technologically polluted waste water from industrial process of the Feni Industry (refining), water from washing (floors of the production halls, streets, vehicles) and the first amounts of storm water in order to collect treat and return to reuse in technological process.

2. Current condition

2.1 General

The system “Ljubosh” supplies the factory with technical and fire water, which takes surface water from the “Dabnichka River”. In case of scarcity of water, recharge is done from the reservoir “Tikvesh”.

Generally, technological water is used for several purposes, such as: process cooling, pelletization, removal of dust, washing of floors and streets, washing vehicles, etc. Technological water should be used with recirculation. In simple terms, the system for raw water “Ljubosh” should only supplement the water losses that occur in the technological process. For instance, the cooling system works that way. However, some systems (e.g. refining system) don't return used water into reuse In addition, the used water, having large concentrations of pollution, is directly discharged in the South Canal outside of Feni Industry. Besides this water, there are other types of water with high concentrations of pollution (water from washing the floors, streets, vehicles and the first amounts of storm water, collected from road and parking) which need to be treated before they are discharged in the outer surface water. Technological water with a high concentration of emission of pollution and storm water from Feni Industry is discharged through two outlets locations (SW-1 and SW-2) in the “South Canal” to the “Black River”. (Figure 1).

2.2 Sewer system

In Feni Industry, there is a separate sewer system to collect and transport the technologically polluted water and storm water (figure1). Table 1 presents sewage links and types of sewerage water, who are flowing into them, and in table 2 the indicators of pollution in outlets places and SW-1 SW-2 are presented.

2.3 Retention pool (lagoon)

In the area of Feni Industry there is a retention pool with a rectangular shape and dimensions 36/80 m, a height of 3 m and a flat bottom which is now used as settling tank.
Having a high concentration of polluting substances, polluted water is discharged in this pool, and from here one amount of the water is used again in the process of production, and the rest amount overflows and outlets in the South Channel. As a consequence of such use of the pool, the current condition of the pool is very bad and it is almost out of function (figure 2).

Table 1. Review of sewerage water and the origin of the waste water

Outlets	Links	Origin of sewage water
SW – 1	KK – 1	- technical water from refining; - outlet water from tank for leveling (lagoon); - technological water from washing the floors of production hall - storm water from streets and roof surfaces of buildings
	KK – 2	- technological water from washing the floors of production hall - storm water from streets and roof surfaces of buildings
SW – 2	KK – 3	- technological water from washing the floors of part of the solution process, processing and transportation of lignite - water from the washing of streets - waste water from washing vehicles - storm water from surfaces of streets, parking lots and roofs.

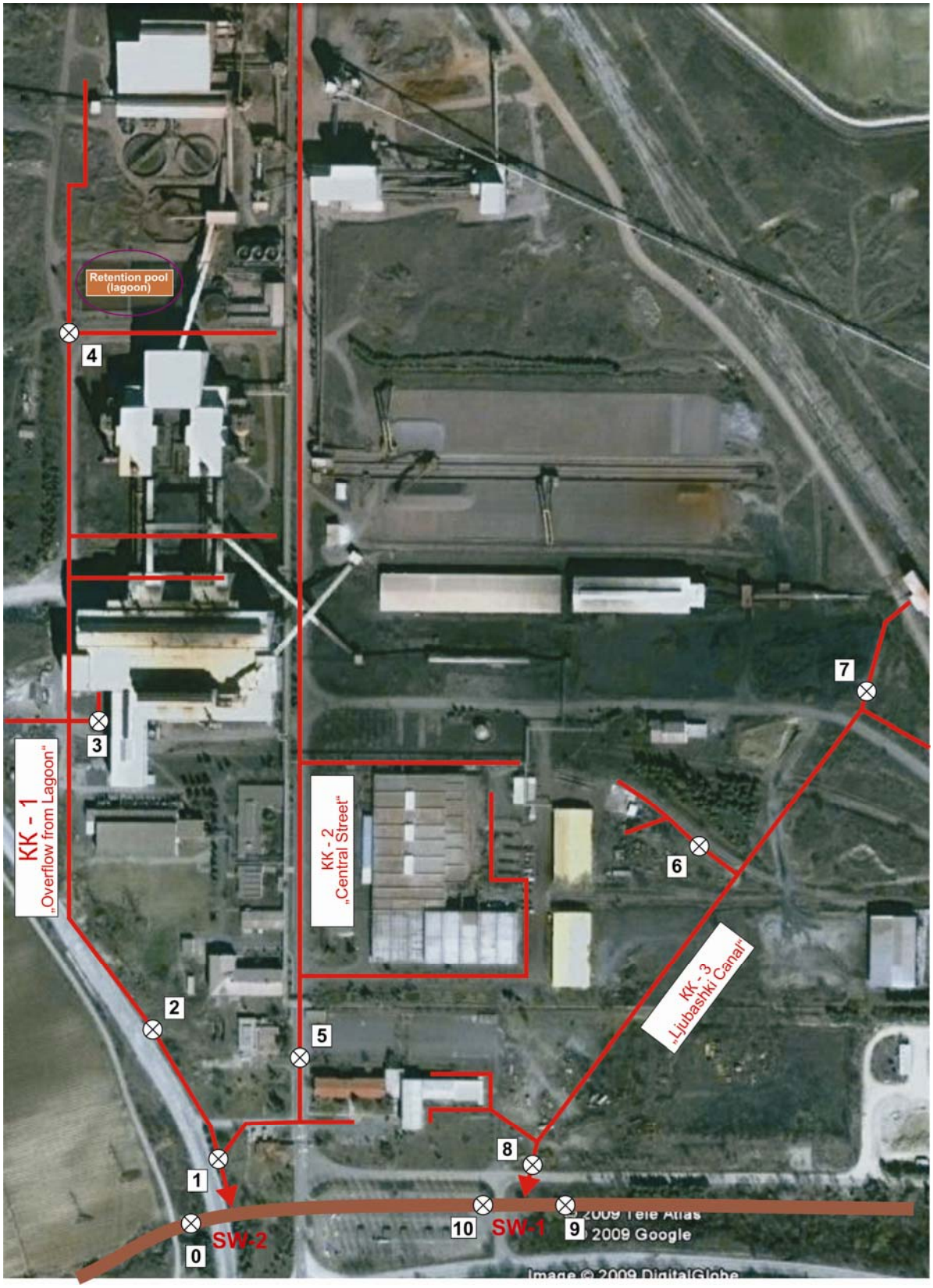

Figure 1. Discharge of technological water in South Canal

Table 2. Indicators and emission of pollution

Place of occurrence		Emission of substances	Indicators of pollution	Quantity $[m^3/h]$
SW-1	depot of lignite	particles from coal	TSS	30
		mud, earth	TSS	
	garage	mud, earth	TSS	
		oil, fat	oil, fat	
	storm water	particles from coal	TSS	
		mud, earth	TSS	
SW-2	washing floors	particles from ore	TSS, Fe, Ni	250
		mud, earth	TSS, Fe, Ni	
	overflow from settling tank (lagoon)	particles from ore	TSS, Fe, Ni	
	storm water	particles from ore	TSS, Fe, Ni	
		mud, earth	TSS	
	refining	particles from ore	TSS, Fe, Ni	
		particles of dead lime	TSS, pH	

2.4 System for recirculation of Refining

Technological water from refining, which is gained by process of removing dust, is with highest concentration of emission of polluting substances (TSS). There is a system for recirculation to the retention pool which system in lately is not in a function. Therefore, the technological water, not treated is discharged into the South Channel. At this moment the system for recirculation is out of operation due to poor condition of the settling tank (figure 2), as well as the problems with the pumping pipeline due to occasionally increased pH (10-12). The increased level of pH is due to occasionally use of $Ca(OH)_2$ as a substance for sulfur removal in the process of rafining.

Figure 2. Current condition of the retention pool

3.Quantity and quality of technological waste water and storm water in Feni Industry

3.1 Definition of measuring points

For the need of this study for the treatment and rational use of water in Feni Industry at Kavadarci, there were made several incidental measurements and assess of the flow of water as well as laboratory analyses of certain parameters to define the quality of water.

The selection of specific measurement points (total 7) is made in consultation with the professional services of the Feni Idustry; taking into account the following:

- To determine the quantity and quality of water in terms of some specific components of polluted water from Feni Industry, as well as technologically water from refining, water from washing the floors, streets, vehicles, storm water and other.
- To determine the quantity and quality of water before and after the discharge of water from Feni Industry;
- To determine the quantity and quality of water which overflows from the retention pool;

At the measurement locations (Figure 1) are made eximinations on the parameters of the water, such as: flow, total suspended solids (TSS), density, carbonates fortress, pH, speed sedimentation, oil and fat, and examinations of parameters of solids (sludge): granulation composition of dry solids and concentration of heavy metals. The value of these parameters variable by time and it depends on the hydrological conditions, production process, characteristics of the ore, type of substance for sulfur removal etc.

Field measurements were conducted in two times, the first one on 05 (where there was a dry hydrological period of ten days) and on 16 (after a period of wet hydrological rainfall on the 13^{th} , 14^{th} and 15^{th}) October 2010.

3.2 Quantity of discharge

At previously defined measurement points, measures are taken and the assessment of quantity of discharge of water and is establish in order to define amounts of water for planned processes and the facilities of the system for treatment and recirculation of water in the technological process in Feni Industry.

Depending on the geometry and the hydraulic conditions of the measurement place, the following methods are used for measurment of the flow:

- Measurement of flow with hydrometric current meter;
- Measurement of flow with weir;
- Measurement of flow with volumetric method.

For measurment of the flow at measurement place "0" is made rectangular weir with a sharp edge (Figure 3). From a figure 3 it can be indicated the water quality in the South Channel after discharging the technologically water of Feni Industry.

Characteristic flows from measurements made on 5^{th} and 16^{th} October, 2009 are schematic shown on the figure 4 and 5.

3.3 Water quality

According to the permission, issued by the Ministry of Environment and Physical Planning, the maximum allowable concentrations (MDK) of emission of polluting substances into the water until and after December 2010 is set. In addiotion, monthly monitoring of the control substances (pH, total suspended solids and the concentration of heavy metals) is set at two measurement stations SW-2 (0) and SW-1 (8). Surface water on the station "0" which is downstream nearby to the outlet of industrial and storm water from Feni and South Canal before Feni Industry must be controlled once a month.

Samples for chemical analysis are also taken from the control points 0, 1, 3, 4, 5, 8, 9.

Water samples, taken from the measurement points 4, 5, 8 and 9 are controlled in terms of:

- ph

- Total suspended solids and
- Oil and fats.

Figure 3. Overflow of MM-0, condition of 16 October, 2009

Summary samples of wastewater, taken from the measurement ponts 0 and 1 are considered as authentic for the study and wastewater from refining, taken from the measurement point 3, as a dominant pollutant are controlled by the following parameters:

- ph
- Total suspended solids;
- Heavy metals in sediment and filtrat;
- Relative density;
- p и m alkalinity;
- Carbonates and total fortress and
- Sedimentations characteristics of water

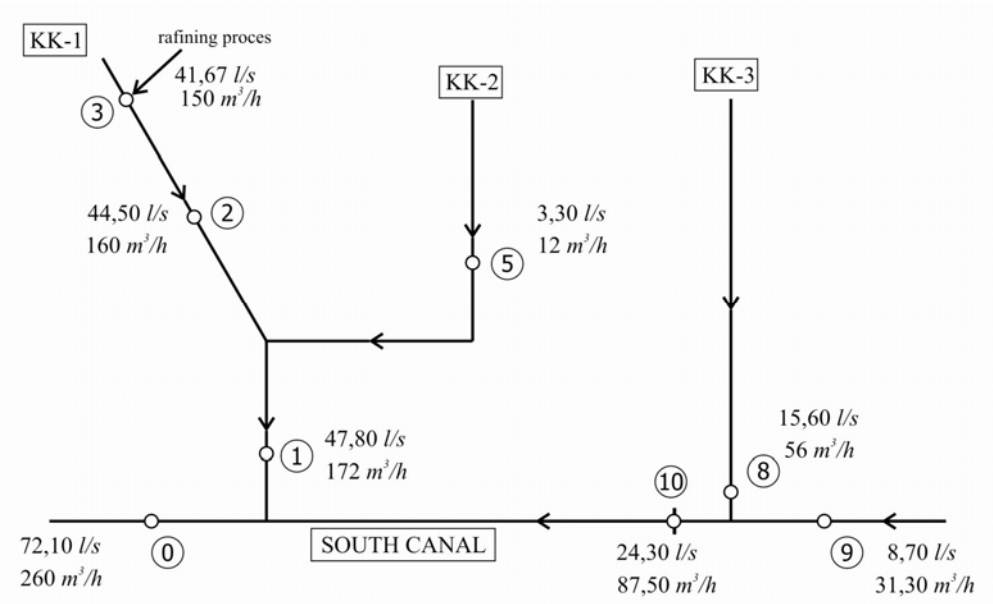

Figure 4. Schematic of the flows measured at 05/10/2009

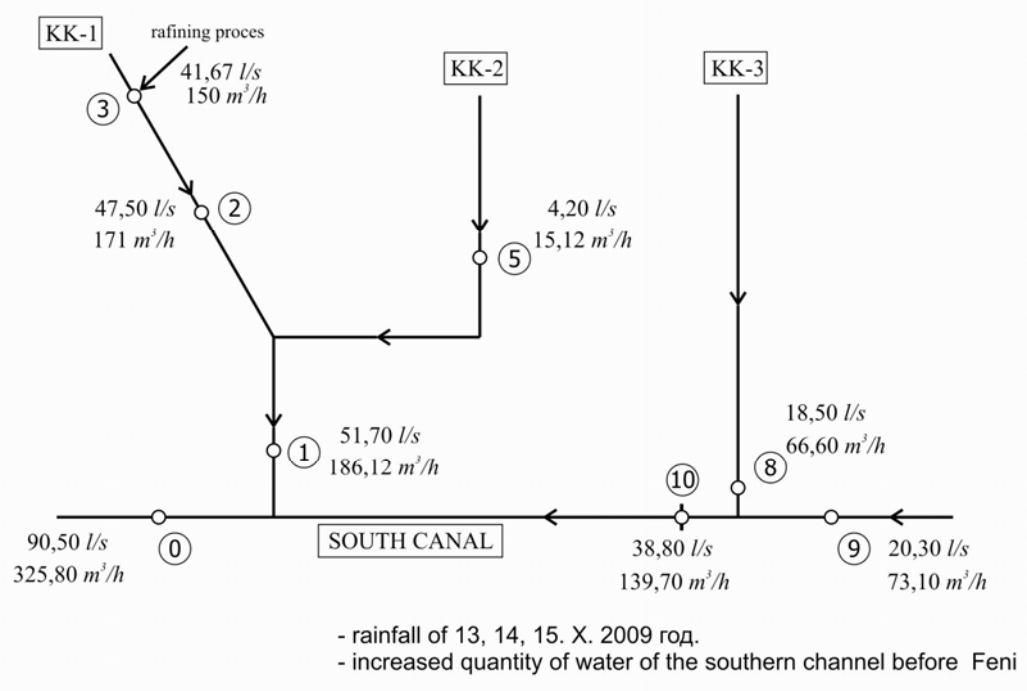

Figure 5. Schematic of the flows measured at 16/10/2009

3.3.1 Results of the chemical analysis of water

Samples for analysis are taken on 5th and on October 16th, 2009. On 05/10/2009, two types of wastewater from Feni Industry are examinated, as follows:

I/ wastewater from defined emitters (separating samples) samples are also taken at the measuring points:

- 3 - Wastewater from refining;
- 4 - Overflow water from settling tank;
- 5 - Wastewater from sewer line II of the storm water;
- 8 - Wastewater from Ljubashki Canal and;
- 9 - Wastewater from South Canal after Feni Industry.

II / Summary wastewater from several emitters are taken from the measuring points:

- 0 - Surface water from the river (the sum wastewater of sewer lines I and II of the storm water drains, Ljubashki Canal and surface water from the river);
- 1 - Wastewater from a collecting manhole (the sum of sewage lines I and II of the storm sewer);
- 3 - Wastewater from refining.

The results of examinations on separated samples of wastewater are shown in Table 3, while the results of the examination of summary samples taken on 05/10/2009 are shown in Table 4 along with results of samples, taken in the river on 16/10/2009. Chemical analysis of summary wastewater of measuring point "1" on 16/10/2009 is not made because of the inability to obtain a homogeneous test from the summary manehole.

Chemical analysis of the wastewater from refining as a biggest emitter of suspended solids and heavy metals in the effluent from Feni Industry were taken and analyzed on 05/10 and 16/10/2009. The results of examinations are given in Table 5, and distribution of heavy metals in sludge (suspended solids) and water (filtrate) is shown in Table 6.

Table. 4. Quality of summary waste water and waste water from refining taken on 05/10 and on 16/10/2009

Parameters	Units	05.10.2009		16.10.2009	
		0	1	0	1
pH	-	6,60	6,70	6,65	-
TSS	mg/l	3895	521	273	-
Relative density		-	1,010	-	-
p alkalinity	mval	0	0	0	-
m alkalinity	mval	2,85	3,25	3,05	-
Carbonates Fortress	ºG	8,18	9,10	8,54	-
Total Fortress	ºG	9,40	9,80	10,12	-
Sedimentation characteristics	mg/h	5,50	0,80	0,50	-
	mg/2h	6,25	0,85	0,70	--
Oil and fats	g/l	0.001	-	0.0017	-

Table 5. Results of the chemical examination of wastewater from refining MM"3"

Parameters	Units	Taken	
		05.10.2009	16.10.2009
pH	-	6,10	6,40
TSS	mg/l	280	398
Relative density	mval	0	0
p alkalinity	mval	2,60	2,70
m alkalinity	ºG	7,30	7,56
Carbonates Fortress	ºG	10,64	8,60
Total Fortress	mg/h	0,20	0,30
	mg/2h	0,30	0,40

Table 6. Distribution of heavi metals in wastewater from refining MM"3"

Parameters	Units	05.10.2009		16.10.2009	
		Sludge	Filtrate	Sludge	Filtrate
Fe	mg/l	95,00	< 1	147,00	< 1
Ni	mg/l	6,51	< 1	16,20	< 1
Co	mg/l	0,36	< 1	0,60	< 1
Cr	mg/l	Not have	< 1	Not have	< 1

3.3.2 Sedimentation substances in water

Estimation of the speed of sedimentation (clarification) of suspended solids present in the water is made by the characteristics of the sediment substances. The speed of sedimentation is investigated at measure points "0" and "3" on the 5th and 16th October, 2009 (figure. 6). An analysis for evaluation of the speed of clarification is made, on samples with increased pH value (pH=12). On the figure can be seen that the speed of clarification with increased value of pH is higher. Thus, that wastewater better and faster can be clarified.

3.3.3 Observations from laboratory examintions on the wastewater

From the flow measurements and the chemical analysis of the technological water (separated samples) it can be indicated that the greatest amount of pollution is carrying the water from refining. The amounts to about 150 m^3/h have a dominant share over the suspended solids, heavy metals and even the pH value in effluent from industry and surface water in a controlled point 0. Although the pH value in wastewater from refining is at limits (6 – 9) should be expected to have increased pH value (above 9), provided changes occur in the means of desulfurization in process of refining. In such cases, neutralization of the water with technical HCl should be provided.

The concentration of suspended solids in water from refining is variable and quite high. The presence of heavy metals in suspended matter is about 35 mass percent which means emission of Fe and Ni in the surface water around 24,4 kg/h.

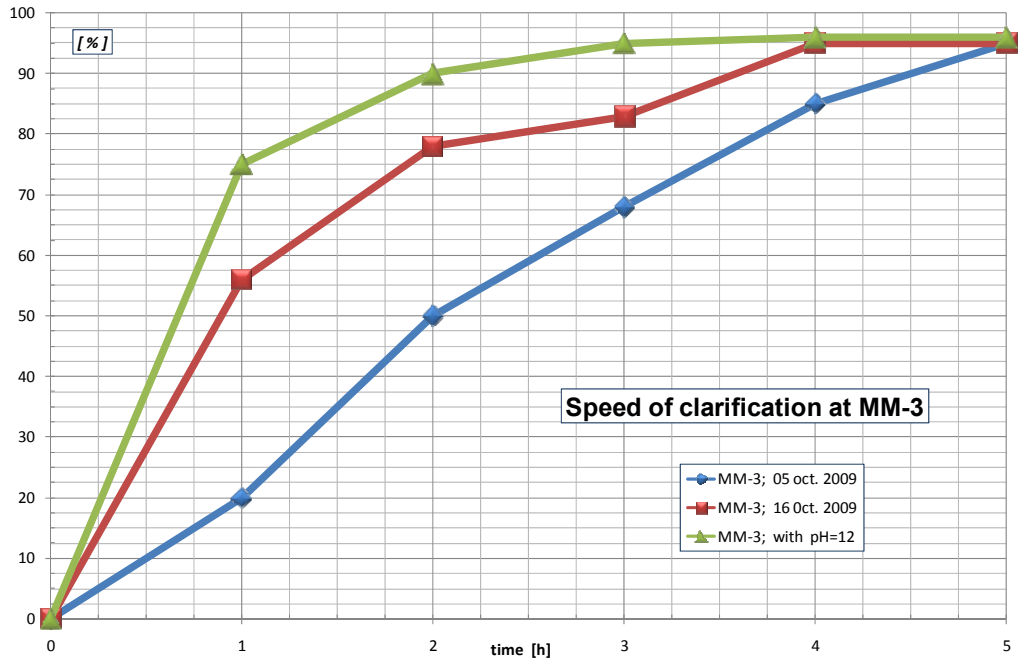

Figure 6. Speed clarification of the industrial water from MM-3 with normal and increased value of pH

The wastewater from refining proved to have good characteristics for sedimentation, so after 2 hours of sedimentation is accumulated about 75% of suspended solids in water around pH 7, and 90% at pH 10 and pH 12. Furthermore, it is also noted that the wastewater from refining in 5 hours sedimentation, achieves a high rate of sedimentation of suspended sollids (more than 95%).

From the examination of sedimentation characteristics of surface water (measuring point 0) and summary water (measuring point 1) it can be indicated that the speed of sedimentation is good and that heavy metals are distributed in the sludge. Thus, reducing suspended solids and the concentration of Fe and Ni in water is achieved. Therefore, the water quality at measuring point "0" will satisfy the norms.

4. Technological scheme for treatment and recirculation of industrial waste water and storm water from Feni Industry

4.1 Basic technological scheme

According to information on the composition and technological characteristics of the polluted wastewater from the producing process of Feni Industries, obtained from the laboratory tests, can be induced that physical methods for purifying the water are sufficient in order to be achieved the required water quality for reuse in the technological process, as well as to be discharged in the recipient of II category.

Namely, the greatest part of the emission is composed of non dissolve suspended polluting substances that can be removed from the water by sedimentation, flotation and filtration. Only in certain cases, when Ca $(OH)_2$ is used as a tool for desulfurization, instead of $CaCO_3$, the refined industrial water is with increased value of pH. In this case, chemical process for correction of pH is necessary to apply.

Many processes and operations need to be composed, within the basic technological scheme for the treatment of industrial polluted water, as follows: mechanical processes of water treatment (sedimentation,

flotation and filtration), mechanical processes of sludge treatment (thickening, dewatering), chemical processes for adjusting the pH, figure 7.

Mechanical processes in water treatment. Sedimentation (precipitation), flotation and/or filtering are applied within the mechanical processes.

Sedimentation. From the laboratory analysis is concluded that during the sedimentation of 2 hours 70 to 90% of suspended solids are sediment or effluent after 2 hours sedimentation would be with concentration of 50 to 70 mg / l suspended solids. While after 5 hours, more than 95% of suspended solids are sediment or effluent after 5 hours of sedimentation would be with concentration of 20 to 30 mg/l. With the 5 hour sedimentation, satisfactory quality of purified water is achieved. In addition, provided would be built new settlings tank, need to be applied chemical methods in order to accelerate sedimentation (coagulation and flocculation), since the sedimentation time of 2 hours is not enough to be achieved satisfactory quality of effluent in terms of suspended solids. As for this case study, where will be used already built settling tank, providing more than 5 hours of sedimentation, the process for acceleration of the sedimentation is not needed - enough only sedimentation.

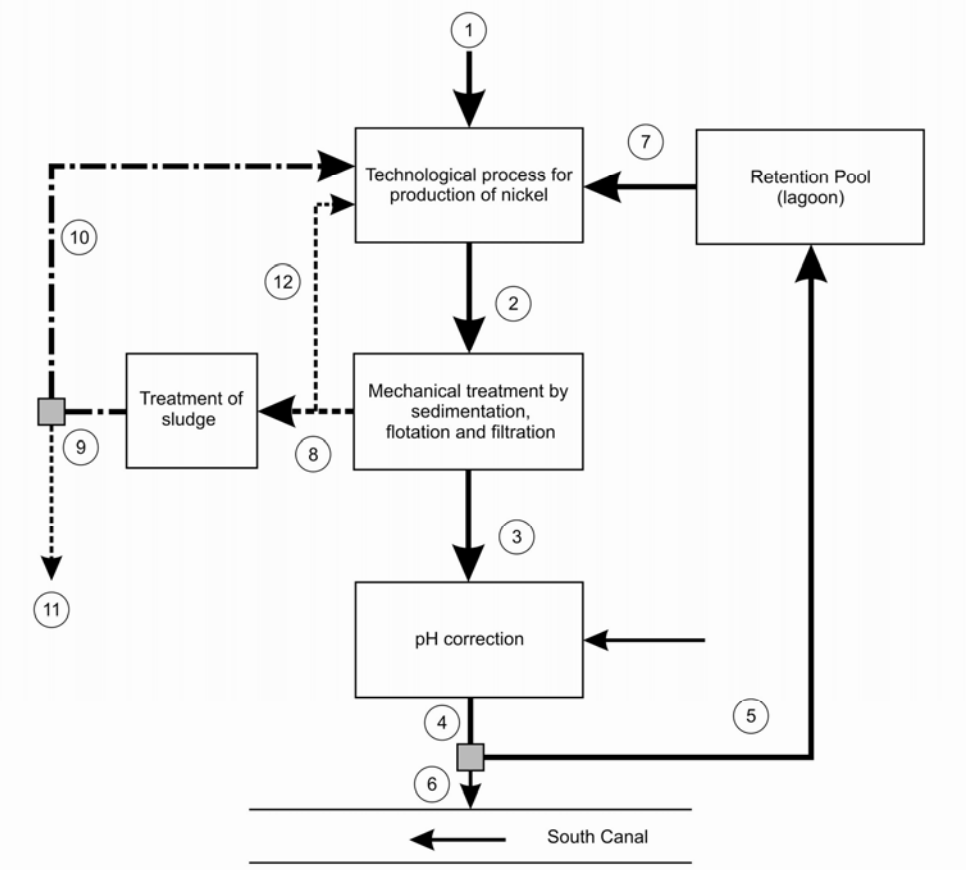

Figure 7. Basic technological scheme for the treatment and recirculation of industrial water in the process of production of Feni Industry

(1) Supply of raw water from the system Ljubash; (2) Industrial polluted water; (3) Water after sedimentation; (4) Water after pH correction; (5) Return treated water to retention pool; (6) Overflow of treated water into the South Canal; (7) Recirculation of treated water in the technological process; (8) Removal of sludge from the process of sedimentation; (9) Dry solids; (10) Return sludge in the production process; (11) Removal of sludge to landfill; (12) Return sludge to process for ore moisturizing

Flotation. For removal of the easier suspended solids from water, special separators are necessary to be build or the flotation need to be implemented in the settling tank. Providing, flotation is implemented in the settling tank, a solution of submerged flow of sediment water from the settling tank need to be applied. Moreover, a system for collecting and evacuation of light polluting substances need to be arranged.

Filtering. The process of filtering will be used for filtering technological water that releases from washing areas where manipulation with lignite is done. The amount of technological water is negligible small compared with the total amount of wastewater. Thus, in the first stage of the treatment, filtration of the waste water from washing areas where lignite is present is not provided. Providing in the process of exploitation occur problems with increased concentration of suspended solids as a consequence of the presence of lignite, on the place of occurrence separation of such substances will be separately applied by applying first the process of sedimentation and flotation and then the process of filtration.

Correction of pH. According to the analysis can be indicated that water with pH value from 10 to 12 has good sedimentation characteristics. However, a neutralization must be performed previously (according to standards) in order to be discharged into foreign surface water and to be used for recirculation in the process. In this case, neutralization will be made with technical HCl. Accordingly, the composition of this system for neutralization in order to be complete has the following constituents: automatic pH probe, (located on the overflow of settling tank), electromagnetic flow sensor (located between the overflow of settling tank and the point of addition of HCl), room and containers for storage of HCl, pumps for automatic dosing and injection of HCL, software and hardware for automatic dosing of HCl depending on the flow of water and pH value, and equipment and facilities for rapid mixing of water and HCL. Reaction and neutralization of the pH value will be implemented in the sedimentation pool for (compensation pool or lagoon).

Mechanical processes of sludge treatment. In this case, in the technological process of production of nickel there is an early stage of moisturizing ore (with water in special mixers) with intention of forming pellets. In consultation with the professional services of Feni Industries no problem is noted if the process of ore moisturizing is done with sludge, or sludge and water from the settling tank. With this ore moisturizing, in technological process a significant amount of copper is returned. Thus a significant economic and environmental benefit is achieved. Therefore, the technological schemes, considered in the study, do not have area for treatment of sludge, i.e. sludge from settling tank is directed directly towards the mixer for ore moisturizing.

Recirculation of treated water. According to information from the professional services of Feni Industries, the average annual use of water, taken from water system Ljubash is 3.800.000 m^3, and the average annual discharge of water, discharged from direct outlets and the SW-1 SW-2 in the South Channel is 2.500.000 m^3/god. Taking in consideration these data, the option of fully implementation of the recirculation system in Feni Industries achieves significant economic and environmental benefits for both Feni Industries and the closer and farther surrounding. In simple terms, the recirculation system in Feny Industries would annually save a large amount of water. In addition, a tank for balancing the current flow quantity which is currently treated and the actual amount of needed water is necessary to be provided.9 . For this purpose, the sedimentation pool would be used.

4.2. Adaptation of existing facilities in treatment of industrial water

Taking into consideration the necessary basic processes and facilities for treatment and reuse of the water in the industrial process for production of nickel and the overview of the built facilities, as well as their current condition, we can note that there are already built facilities in Feny Industries which can be put into operation, after having some reconstruction first.

As important permanent structures that can be put into operation for water treatment and reuse of the water, are following facilities:

- One from the existing thickeners of nickel;
- Sedimentation pool (which has been used as a sedimentation settling tank);
- System for recirculation of industrial water of refining
- Greater part of the storm sewer (KK-1, KK-2 and KK-3).

4.3. Possible technological schemes for treatment and recirculation of water

When selecting processes and facilities of the technical scheme for treatment and recirculation of industrial water and one part of the storm water of Feni Industries, as well as their spatial location, the following criteria need to be taken into consideration:

- Maximum recirculation use of the industrial water;

- Purified water in terms of its quality, need to meet the water quality of II category of river;
- Place of occurrence, quantity, quality and the durance of the contaminated water would be treated and reused;
- Maximum utilization (adaptation) of existing built facilities that are not currently in operation or have poor function;
- The spatial location of the existing facilities that could be used, as wll as the direction of flow and the outlets of the existing sewage in the South Canal.

Considering the previously specified criteria, we can generally define two main concepts of possible technological schemes for treatment and reuse of the water from the Feni Industries:

- I option. Treatment of water, concentrated before the outlets in the South Channel.
- II variant. Treatment of water, concentrated in the built thickeners which are not in function, and are before sedimentation pool.

Description of Option I. Provided the treatment of the industrial water is performed at the lowest part, before discharging the water in the South Channel, a new settling tank has to be constructed. The new settling tank need to be built with dimensions in terms of accumulation of water up to 2 h. According to the laboratory tests, can be stated that with 2 hours of accumulation, the required water quality in terms of suspended solids will not achieved. Therefore, the required quality of the effluent, will be gained only by applying chemical methods with the aim of increasing the efficiency of sedimentation (coagulation and flocculation). The solution in terms of building a new settling tank with part of coagulation and flocculation will significantly increase the investments for the realization of the treatment system and reuse of water. This kind of technological scheme need to contain pumping station in regard to pump the treated water to the sedimentation pool. A critical issue in this scheme will be the technical problem with the sludge. The sludge treatment need to be done near the settling tank (near the Southern Channel). The other option is to pump the sludge to the great height and length up to the mixer of ore moisturizing. The problem with sludge pumping up to the mixer will often be a problem during the exploitation period. If the treatment of the sludge will be designed close to settling tank, the required space of the plant for treatment of industrial water will increase. Moreover, the area near the outlet SW-2 has not enough space for that purpose, also the required space is outside the circle of the Feni Industries. Therefore, this issue may cause property legal problems.

Taking into consideration the stated conclusions, the first option becomes inadequate compared to the second option, whereas the treatment of water is designed in the circle of the plant and near the existing facilities, used for the new technological scheme (settling tank, pool for leveling, mixer and other).

Description of Option II. The second option provides a treatment of industrial water, planned near the existing facilities, which will be put into operation in the process of purification. The sedimentation of the industrial water is done in one of the existing thickeners for nickel and the sedimentation pool (Lagoon). Within this option, three sub options are reviewed. The difference in the three options is only in the part of the recirculation of the technological water from refining and the location of the flotation section for the oils that occasionally occur in the technological water. The three sub options are described below, as follows:

- Option II-1. Flotation, designed down to the main pumping station and the recirculation of the water to be made from the main pumping station located near the outlet SW-2.
- Option II-2. Flotation, designed in the smaller thickener for iron in order to maintain the existing system for recirculation from refining and with its connection to the new pump pipeline.
- Option II-3. Flotation, designed in the radial settling tank (thickener for nickel) in order to maintain the existing system for recirculation from refining and with its connection to the new pump pipeline (Figure 8).

In all three option II-1, II-2 and II-3, besides the option I, the existing thickener for nickel is included in the technological scheme for the process of sedimentation. The volume of the thickener is V = 1780 m^3. According to the rudimentary estimates of the designed recirculation flow, the hydraulic retention time (sedimentation) would be approximately 5 to 7 hours. Furthermore, the results of the laboratory tests (speed clarification) showed satisfactory quality of the effluent if the time of sedimentation is 5 to 7 hours. In simple terms, the design does not require other chemical processes and structures to accelerate the process of sedimentation. Thus, the three options are economically more profitable compared to the option I.

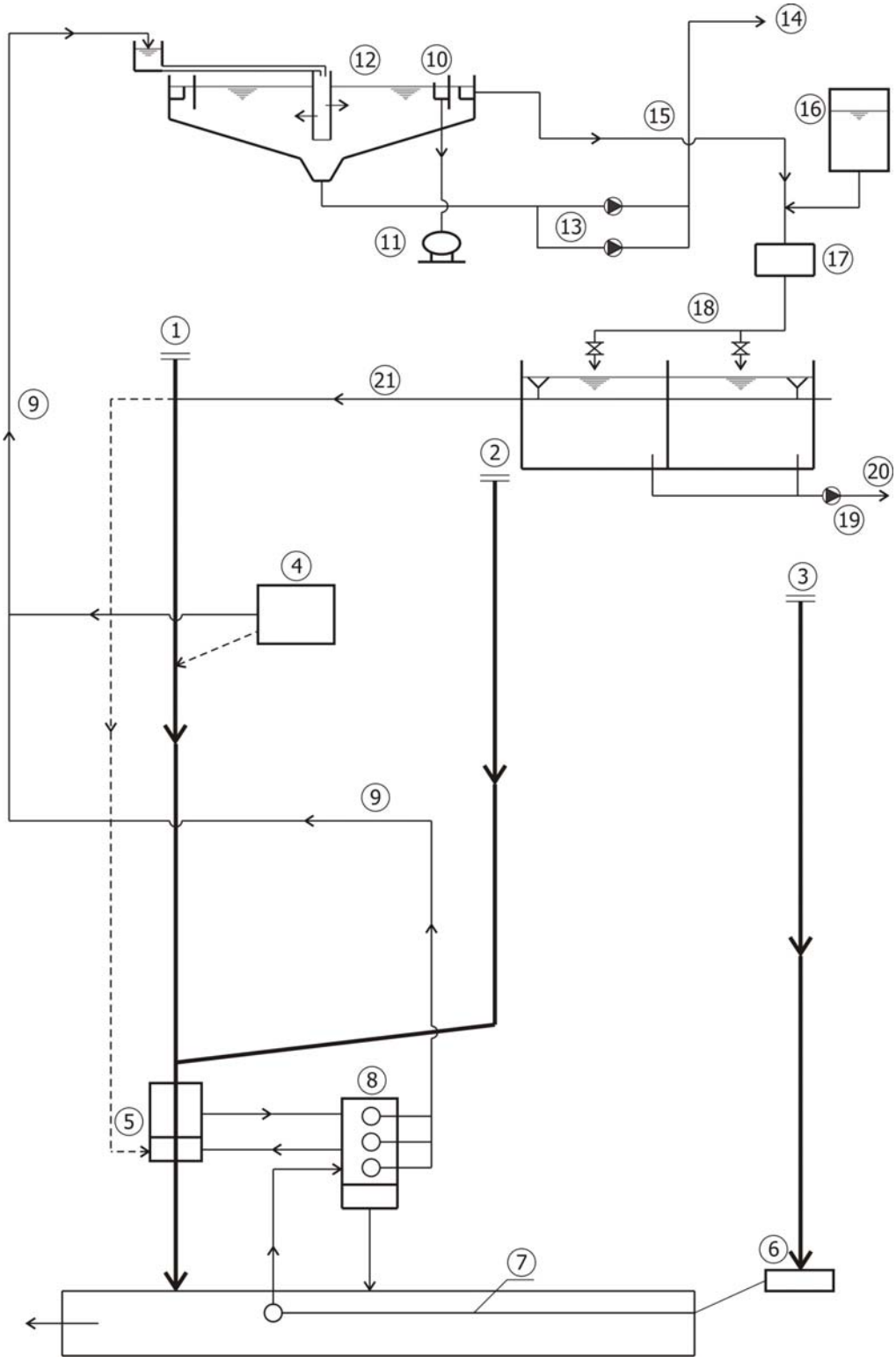

Figure 8. Technological scheme for variant II-3 for treatment and recirculation of water.

(1) Sewer pipe 1 (KK-1); (2) Sewer pipe 2 (KK-2); (3) Ljubashki Canal (KK-3); (4) Refining proces; (5) Overflow; (6) Intake of Ljubashki Canal; (7) Supply to the pumping station; (8) Pump station; (9) Pump pipeline; (10) Oil separator; (11) Oil tank; (12) Sedimentation tank; (13) Pump for sludge; (14) Pumpline to mixer; (15) Outlet of clean water; (16) Addition of chemical reagents to adjust the pH; (17) Rapid mixing; (18) Pipeline to the retention pool– Lagoon; (19) Pump station; (20) Drain to reactor; (21) Overflow from lagoon.

Option II-1 compared with options II-2 and II-3, requires larger object (oil separator and pumping station) at outlet SW-2, whereas the oil separator is planned to be build. Therefore, the foundation depth of the pump station is increased. This conclusion makes option II-1 more expensive than the other two options (II-2 and II-3). In addition, option II-1 do not maintain the existing system for recirculation of technological water from refining, i.e. all technological water is collected in the pump station located at SW-2. Therefore, the capacity of the pump station need to be greater than the capacity of the pump stations from the other two options II-2 and II-3. According to previous, not only the capital investment will be increased, but also the exploitation costs in option II-1 will be larger than the exploitation costs from the other two options II-2 and II-3. This conclusion is as a result of the larger annual water volume, pumped from the lowest point of the system, i.e. from the pumping station at SW-2, which is 200 meter height above sea.

Both options II-2 and II-3 are very similar between themselves. The difference between these two options is only in the process of flotation. In the option II-2, the process of flotation is designed in the thickener of iron. The outlet from the thickener of iron is in the peripheral canal. The elevation of this outlet is higher than the height of the inlet channel for the thickener of nickel. Meaning, the option II-2 would spend more energy than the option II-3.

In the option II-3, the process of flotation is designed in the radial settling tank. Meaning, the thickener of iron would not be included in the technological scheme for the treatment and recirculation water use. Thus, it would be free for another purpose. Furthermore, the funds for the adjustment of thickener of iron into separator for oil would be greater than the ones for the realization of the process of flotation in radial settling tank.

Taking into consideration the previous conclusions, can be concluded that the three under options II-1, II-2 and II-3 have more advantages than of the option I.

Optios II-2 and II-3 do not differ very much. Option II-3 have certain small advantages in comparison with option II-2. According to previously stated, as a final option of the technological scheme for the treatment and recirculation use of the technological water from Feni Industries is suggested optionII-3 (Figure 8).

5. Conclusion

The aim of this study for treatment and rational use of water from Feni Industries in Kavadarci is appropriate treatment of the industrial water of the producing process and its return to reuse with possible use of the existing facilities for water treatment. With the realization of this idea few important benefits are realized, as follows: gaining economic benefits, reducing investments for construction of the facilities necessary for treatment of industrial water, reducing the cost for providing raw water for Feni Industries, providing larger quantities of water for other uses (for irrigation and electricity production); and achieving environmental benefits, through prevention of the pollution of surface and groundwater.

References

Pelivanoski, P., Veljanoski Z., Maletic M., Taseski G., & Maletic A., 2010: *Treatment of Technological Water from Feni Industry – Kavadarci and Reuse, Feasibility Study, Ss. Ciril and Methodius University – Faculty of Civil Engineering, Skopje 2010.*

P. Pelivanoski P., Donevska K. Sofronievska D., 2009: *Waste water and Landfill Leachate Treatment plant for the Municipality of Cenatar Zupa, 11th International Symposium on Water Management and Hydraulic Engineering (IWMHE-2009), 441-452, Ohrid, Macedonia, sept. 2009*.

Donevska K., Pelivanoski P., 2009: *Treatment Plant for Combined Treatment of Landfill Leachate and Domestic Sewage Wastewater, 13th International Symposium of Macedonian Association of Structural Engineers, 595-603, Ohrid, Macedonia, octob. 2009.*

W. Fresenius and W. Schneider *, Waste Water Technology – Origin, Collection, Treatment, and Analysis of Waste Water; institute Fresenius GmbH, Taunusstein-Nauhof, Berlin 1989*