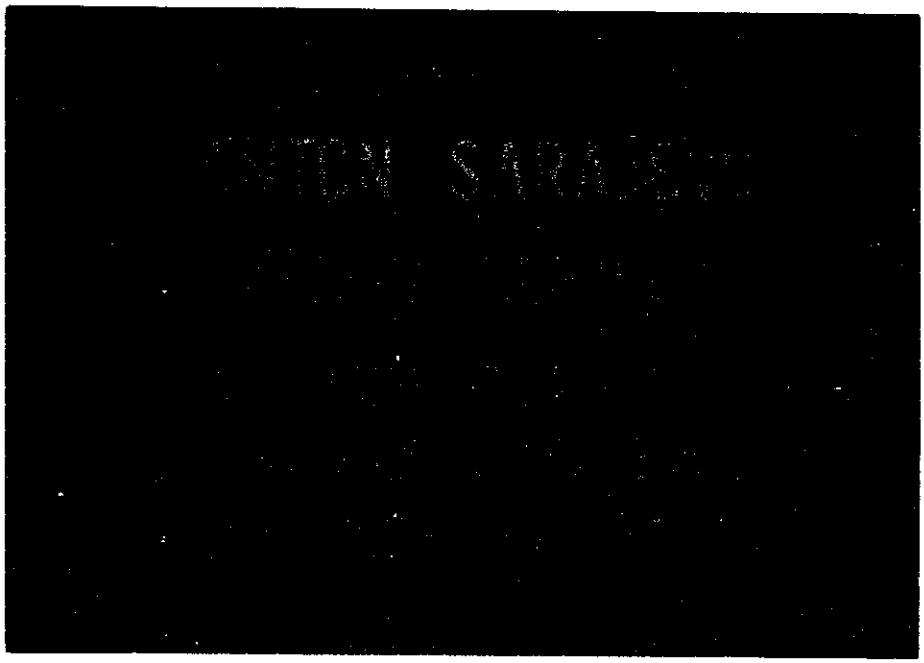
N. ENVIRONMENTAL IMPACT ASSESSMENT



APPENDIX N. ENVIRONMENTAL IMPACT ASSESSMENT

LIST OF TABLES

LIST OF FIGURES

APPENDIX N ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

N . 1 . INTRODUCTION

Summary of relevant parts of existing laws on industrial effluent discharge to sewerage system, air quality standards and discussion on permissible WWTP effluent quality based on river classification are provided in this supporting report. It is referred in **Section 2.8 of Water Quality and Environmental Conditions** and in **Chapter 8 Environmental Impact Assessment** of the **Main Report.**

N . 2 . INDUSTRIAL EFFLUENT STANDARD FOR DISCHARGE TO PUBLIC SEWERAGE SYSTEM

These regulations for Sarajevo City was enacted following the construction of Sarajevo WWTP prior to winter Olympics. **Table** N. 1 shows the allowable concentrations.

TableN.1 INDUSTRIAL EFFLUENT STANDARDS FOR DISCHARGE IN TO PUBLIC SEWERAGE SYSTEM

Parameter	Limit
Temperature	less than 40°C
BOD_5, at 20°C	500 mg/L
Total suspended solids	500 mg/L
Sediment	0.5% or 5 mL/L
Sulphates (SO_4^{--})	400 mg/L
pH	between 5.5 and 9.5
Mineral oils and fats	40 mg/L
Vegetable oils and fats	100 mg/L
Nitrate (NO_3-)	100 mg/L
Nitrite (NO_2-)	10 mg/L
Sulfide (S^{--})	2 mg/L
Total Chromium (Cr)	5 mg/L
Hexavalent Chromium (Cr^{6+})	2 mg/L
Copper (Cu)	3 mg/L
Zinc (Zn)	5 mg/L
Nickel (Ni)	3 mg/L
Iron (Fe)	20 mg/L
Lead (Pb)	2 mg/L
Anionic surfactant	10 mg/L
Arsenic (As)	2 mg/L
Cadmium (Cd)	2 mg/L
Radioactive substance	10 - 12 kirija/L

EXCERPT FROM THE CANTON SARAJEVO LAW ON INDUSTRIAL EFFLUENT DISCHARGE TO PUBLIC SEWERAGE SYSTEM

"GENERAL TECHNICAL CONDITIONS ABOUT PROTECTION OF CITY SEWERAGE SYSTEM AND WASTEWATER TREATMENT PROCESS OF SARAJEVO- INCLUDE PART OF DECISION ABOUT WATER AND SEWERAGE SYSTEM"

1. GENERAL PART

1.1 General technical conditions about protection of city sewerage system and wastewater treatment process are relate to public sewerage network including all facilities in it and in city treatment wastewater plant.

1.2 By general technical conditions are issued technique, sanitary and the other conditions for type and quality of water that can be discharged into city's public sewerage.

1.3 For Sarajevo city uses separate sewerage system.

1.4 Water which is drained by rain canals lets without treatment into recipient and fecal(used) and pollution water delivers on treatment wastewater plant of Sarajevo.

2. PROTECTION OF FUNCTIONALITY OF SYSTEMS OF SEWERAGE FACILITIES AND EQUIPMENT

2.1 Can be let into storm sewers :

- atmosphere- hillside water
- spring water and water currents of less capacity
- drainage water except water drainage graveyards, trash heaps and similar lands.
- water of big cover parking places with precede treatment of oil.
- water of industry plateaus that do not have pollution atmosphere
- rain water from public lands and grounds
- overflow water of tanks
- overflow water of overflow weir on combined sewerage system

All other matters which are not written here can't be let into storm sewers.

2.2 Wastewater discharge without treatment or with treatment, depend of quality and quantity of water

Wastewater means:

- all household wastewater
- wastewater of public places, hospitals etc.
- wastewater of craft works
- industry wastewater

- pump station service wastewater etc.
-drainage water of graveyard, trash heaps etc
- water of overflow constructions on combined system of sewerage
- other pollution water that can not be discharged into water courses, by law

2.3 Conditions of using public sewerage, depend of quality wastewater, for all users are determined by work organization that operates sewerage system, according to the provisions of general technical conditions.

3. PROTECTION OF MECHANICAL INFLUENCES AND CORROSION OF CONCRETE AND CEMENT

3.1 Wastewater that lets into public sewerage system can not contain:
- any liquids that have temperature higher than 40 degrees
- water which contains total suspend matters more then 500 mg/L
- any sediment matters in wastewater more then 0,5% or 5mL/L
- hard and viscous matters as garbage , ashes, trash of metals, plastic, tree trash, glass, cotton, wool.
- wastewater in which there are waste matters which with their abrasion effects make damages walls of sewer
- harmful gases as hydrogen sulfide, sulfur dioxide, nitrogen oxides, chlorine etc.

3.2 For protection of sewerage system from aggressive effect of sulfates, the most allowable concentration of sulfate ion in wastewater which discharged into city sewerage, is determined to be 400 mg/L

3.3 Concentration of hydrogen ions (pH) of wastewater which discharged into public sewerage system can not be less then 5.5 and not more then 9.5

4. PROTECTION OF INFLAMMABLE AND EXPLOSIVE MATTERS

4.1 Wastewater that discharged into public sewerage system should not contain any heavy liquid or gas matters which are inflammable.

4.2 Provisions from preceding paragraph do not contain wastewater which discharged into public sewerage system, and which does not contain inflammable and explosive matters in exceeding the quantity shown in the following:
- organic solvent and easily evaporable oil derivatives
- mineral oils and fats 40 mg/L
- vegetable oils and fats 100 mg/L

5. PROTECTION OF HARM EFFECTS OF CHEMICAL MATTERS

5.1 Needn't let into public sewerage system wastewater in which there can find matters in quantity harmless for citizens, workers, installations, construction of city sewerage

system and on technology of treatment wastewater.

5.2 Specially from provision of precede paragraph wastewater can contain harmful matters of chemical characteristics in the following concentrations:

chromium total- 5mg/L
chromium - 2mg/L
coupon- 3mg/L
zinc- 5mg/L
nickel- 3mg/L
iron - 20 mg/L
lead - 2mg/L
cyanide - 2mg/L
detergents - 100mg/L
arsenic - 2mg/L
cadmium - 2mg/L
sulfides - 2mg/L
nitrates - 100 mg/L
nitrites - 10 mg/L
radioactive matters - 4.10-12 kirija/L

5.3 Value of biological of oxygen demand in test with wastewater sample in 5 days, in wastewater that discharged into city waste system should not be more than 500 mg O_2/L For special situations, sewerage operating organization can allow discharge into public sewerage system with value of BOD_5 more than 500 which determines conditions and way of discharging wastewater.

5.4 All health facility and veterinary organizations and all Ass. labor organizations in which might be found carriers of diseases in higher concentration than found in city wastewater put under special treatment of disinfection before the discharge.

6. CONTROL OF WASTEWATER COMPOSITION

6.1 Supervision of wastewater composition for discharge in to public sewerage system does:
- regular analyses
- extraordinary analyses

6.2 Regular analyses do users of sewerage system on their own way or by authority of operating organization

6.3 During regular analysis checks of physical, chemical and biologic characteristics of wastewater depending on technical process of sewerage system users.

6.4 Type, method and number of analyses determined by authorized person of operating organization

6.5 Extraordinary analyses to be conducted in urgent situation, damages on installations which can occur due to discharge of wastewater into public sewerage to the degree for pollution and also endanger health of citizens and workers who work on maintenance of installations, facilities and treatment process.

6.6 Samples of wastewater needed for analysis is to be taken at manhole on discharge of the particular wastewater before it's discharge into public sewerage system.

6.7 At industries which have installations for wastewater treatment and should always maintain and use in correct condition, samples have to be taken at the outlet of wastewater treatment before overflowing into public sewerage system.

6.8 When taking samples of wastewater needed for regular analyses following records need to be taken:

- date of taking sample
- place of taking sample
- weather conditions
- temperature of wastewater
- appearance of wastewater
- smell of wastewater
- color of wastewater
- flowing of wastewater

6.9 In the report of analysis, note the following.

They are:

- date of taking samples
- name of the main industry from where samples are taken
- place of taking samples
- weather condition
- air temperature
- temperature of wastewater
- appearance of wastewater
- smell of wastewater
- color of wastewater
- flowing of wastewater
- surname and name, together with responsibility of persons who are present at taking samples.

7. FINAL PROVISIONS

7.1 Protection of sewerage system from inflammable liquids by building pretreatment plants for separating them before discharge of wastewater into city sewerage system.

7.2 Sewerage system protection of mechanic effects of hard matters attains by building

plants for their separation before discharge of wastewater into city sewerage system.

7.3 Sewerage system protection of chemical matter should be attained by building adequate plants for neutralization and treatment by the internal sewerage at the polluter side.

7.4 Protection from infective water of sewerage system should be attained by special treatment across some adequate plants for water disinfection.

7.5 Projecting and building plants for protection of explosive, physical and chemical influences and infective water are obligation of polluter.

7.6 Agreement for using type of plant for city sewerage system protection and also as the way of functioning and controlling work is regulated by operating organization.

N . 3 . AIR POLLUTION AND NOISE

Canton Sarajevo has enacted a law on air pollution in 28 May 1999. Air quality standards and emission standards for stationary sources such as generators/boilers are specified. Standard for hydrogen sulphide is 7 μ g/m^3 which is relevant to WWTP operation. Regards to generators where methane gas from the digestor will be used and CO_2, SO_2 and NO_2 will be released to the atmosphere. These generators are designed for dual-fuel type either with digestor gas or with oil. Selection of the gas engines should satisfy the air pollutant criteria shown for the particular capacity of the generator. **TableN.2** shows the air quality standards for Canton Sarajevo.

TableN. 2 CANTON SARAJEVO AIR QUALITY STANDARDS, 1999

Parameter	Sample duration	Limit
Sulfur dioxide (SO_2)	1 hour	350 μ g/m^3
	24 hour	125 μ g/m^3
	1 year	50 μ g/m^3
Nitrogen dioxide (NO_2)	1 hour	300 μ g/m^3
	24 hour	150 μ g/m^3
	1 year	50 μ g/m^3
Hydrogen Sulphide	30 minutes	7 μ g/m^3
Ozone	1 hour	150 μ g/m^3
	8 hour	110 μ g/m^3
	24 hour, non-vegetative period	65 μ g/m^3
	24 hour, vegetative period	60 μ g/m^3

N . 4 . CLASSIFICATION OF WATER COURSES

Classification of water courses in the federation as shown in **TableN.3.** Water quality criteria for river category are shown in **Figure 2.8.1** of Main Report.

TableN.3 CLASSIFICATION OF WATER COURSES

No.	River Stretch	Class
1	Una River	
	a) from the border of Croatia to Martin Broda	I
	b) from Martin Broda to confluence with Sava River	II
2	Sana River	
	a) from the spring of origin to Prjiedora town	II
	b) Prjiedora town to confluence with Unu River	III
3	Unac River	
	a) from the spring of origin to Drava town	I
	b) from Drava town to confluence with Unu River	II
4	Vrbas River	
	a) from the spring of origin to Gornjeg Vakufa town	I
	b) from Gornjeg Vakufa to Banja Luka town	II
	c) form Banja Luka town to confluence with Sava River	III
5	Pliva River	
	a) from the spring of origin to Lake Plivskog	I
	b) from Lake Plivskog to confluence with Vrbas River	II
6	Ukria River	II
7	**Bosna River**	
	a) from the spring of origin (Vrelo Bosne) to confluence with Zeljeznica River	I
	b) **from the confluence of Zeljeznica River to confluence of Miljacka River**	**II**
	c) **from the confluence of Miljacka River to confluence of Sava River**	**III**
8	**Miljacka River**	
	a) **from the spring of origin to New Sarajevo Wastewater Treatment Plant**	**II**
	b) **from New Sarajevo Wastewater Treatment Plant to confluence of Bosna River**	**III**
9	Stavnja River	III
10	Zgosca River	III
11	Lasva River	II
12	Spreca River	
	a) from the spring of origin to Modrac depot	II
	b) Modrac depot	II
	c) Modrac depot to confluence with Bosna River	III
13	Jala River	
	a) from the spring of origin to Tuzleu Town New Wastewater Treatment Plant	II
	b) Tuzleu Town New Wastewater Treatment Plant to confluence of Sprecu River	III
14	Drina River	II
15	Lim River	II
16	Sava River	
	a) from confluence of Una River to confluence of Bosna River	II
	b) from confluence of Bosna River to confluence of Tolise River	III
	c) from confluence of Tolise River to confluence of Drina River	II
17	Neretva River	
	a) from the spring of origin to Ulog camp	I
	b) from Ulog camp to the republic border	II
18	Trebisnjica River	
	a) from the spring of origin to Gorica Dam	I
	b) Gorica Dam and downstream	II
19	Coastal area between Neum town and Klek town	II

N . 5 . FLOW DATA FOR MILJACKA RIVER AND BOSNA RIVER AND ESTIMATION OF TREATED EFFLUENT QUALITY TO SATISFY THE CATEGORIZATION OF WATER COURSES (SR BiH, broj 2/67, 1980)

N. 5.1 MINIMUM FLOW

River flow data for Miljacka River and Bosna River near WWTP are available only between 1926-1974 for the following three locations as provided by the Hydro-meteorological Department. (In 1998 December, a gauging and monitoring station was constructed at Reljevo.)

Station	: Miljacka-usce	
Chainage	: 0.25 km	
Coordinates	: 43° 52' 07" N	18° 17' 45" E
Drainage area	: 398.40 km^2	
Zero water level	: 481.88 m	
$Q_{95\%}$	= 0.702 m^3/sec	

Station : Bosna - uzv		
Chainage	: 266.65 km	
Coordinates	: 43° 52' 10" N	18° 17' 20" E
Drainage area	: 730.0 km^2	
Zero water level	: 481.94 m	
$Q_{95\%}$	= 2.6 m^3/sec	

Station : Bosna - nizv		
Chainage	: 266.75 km	
Coordinates	: 43° 52' 20" N	18° 17' 48" E
Drainage area	: 1132.0 km^2	
Zero water level	: 481.90 m	
$Q_{95\%}$	= 3.67 m^3/sec	

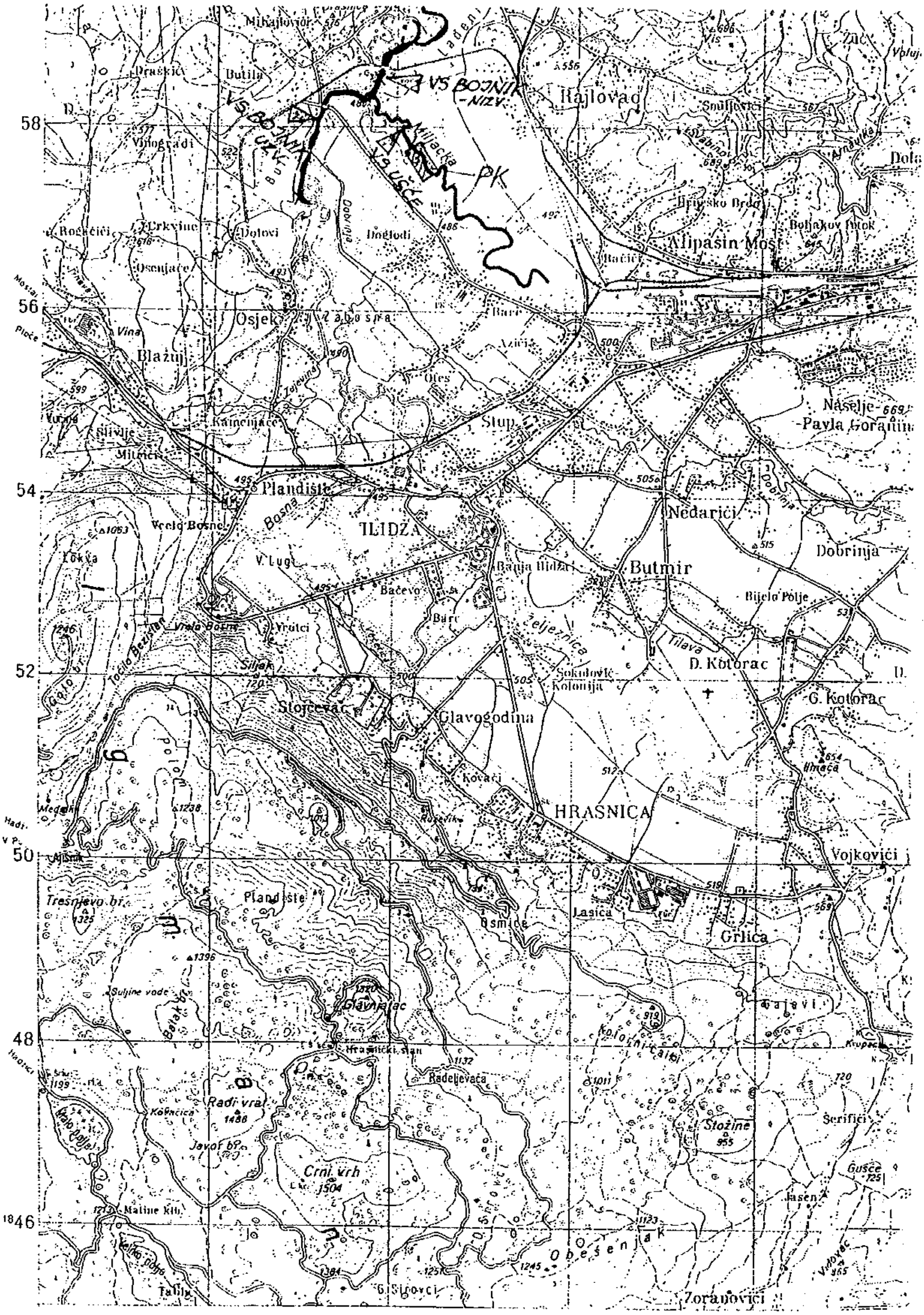


Figure N.1 LOCATION OF GAUGING STATIONS (1926-1974)

Bosna River (flow in m^3/s)
1926-1974

Station : **Bojnik-nizvodno**
Longitude 43° 52' 20" E
Latitude 18° 17' 46" N
Chainage of statio 265.75 km
Drainage area 1132.00 km^2
Datum of Gauge 481.9 m above MSL

Month	Cumulative Percentage %													
	0.1	1	5	10	20	25	30	50	70	75	80	90	95	99
January	124.0	88.0	62.3	50.9	39.2	35.3	32.0	22.7	16.2	14.5	13.1	10.1	8.5	6.8
February	103.0	79.1	59.1	50.3	40.8	37.5	34.9	26.2	19.2	17.5	15.7	11.6	8.7	4.9
March	98.1	79.2	65.2	58.6	50.5	47.8	45.1	38.6	29.6	27.7	25.8	20.4	16.5	10.0
April	129.0	102.0	81.3	71.2	60.2	56.6	53.4	42.9	33.8	31.5	29.2	23.8	19.6	13.3
May	101.0	83.0	67.9	60.7	52.3	49.5	47.1	38.3	30.8	28.8	26.7	22.8	17.1	10.0
June	61.9	50.3	41.4	36.7	31.5	29.5	28.1	22.7	18.0	16.5	15.4	11.8	9.5	5.6
July	45.4	36.0	28.6	25.1	21.2	19.0	18.6	14.8	11.6	10.7	9.8	7.7	6.3	3.8
August	36.5	28.1	21.7	18.7	15.4	14.3	13.3	10.3	7.72	7.2	6.5	4.9	3.8	2.2
September	45.0	34.2	26.1	22.3	19.0	16.8	15.7	11.8	8.7	8.0	7.2	5.4	4.2	2.4
October	86.3	64.0	47.1	39.7	31.5	28.6	26.5	19.2	13.6	12.0	10.7	7.4	5.5	2.8
November	117.0	88.9	67.3	57.5	46.6	42.9	39.7	29.7	21.8	19.5	17.1	13.2	9.9	5.3
December	135.0	97.2	70.1	58.9	46.7	42.3	38.7	29.4	22.0	20.3	18.6	15.2	13.6	11.5
Minimum flow	36.5	28.1	21.7	18.7	15.4	14.3	13.3	10.3	7.7	7.2	6.5	4.9	3.8	2.2

Miljacka River (flow in m3/s)
1926-1974

Station : **Miljacka-usce**
Longitude 43° 52' 07" E
Latitude 18° 17' 45" N
Chainage of statio 0.25 km
Drainage area 398.4 km^2
Datum of Gauge 481.88 m above MSL

Month	Cumulative Percentage %													
	0.1	1	5	10	20	25	30	50	70	75	80	90	95	99
January	31.50	21.80	14.80	11.80	8.88	7.86	7.08	6.64	3.29	2.94	2.63	2.06	1.80	1.53
February	22.50	17.90	14.40	12.50	10.50	9.73	9.09	6.90	4.88	4.35	3.79	2.43	1.12	0.87
March	28.00	22.50	18.20	16.00	13.80	12.90	12.20	9.76	7.59	7.07	6.49	4.99	3.90	2.14
April	33.50	26.10	20.50	17.80	14.80	13.80	13.00	10.30	7.93	7.32	6.71	4.69	4.23	2.50
May	28.50	21.90	16.70	14.40	11.70	10.80	10.00	7.53	5.44	4.94	4.40	3.08	2.18	0.90
June	18.90	14.30	10.60	8.97	7.16	6.56	6.01	4.40	3.06	2.68	2.37	1.63	1.08	0.36
July	20.00	13.60	9.30	7.43	5.53	4.90	4.40	2.90	1.87	1.64	1.41	0.96	0.73	0.51
August	15.20	9.72	6.13	4.62	3.23	2.82	2.43	1.53	1.09	1.01	0.93	0.82	0.78	0.76
September	17.90	12.00	7.84	6.26	4.48	3.85	3.37	2.03	1.53	1.11	0.72	0.38	0.22	0.14
October	35.20	23.70	15.70	12.20	8.66	7.46	6.52	3.97	2.08	1.66	1.33	0.63	0.32	0.16
November	26.90	19.60	16.60	12.30	10.00	9.27	8.66	6.90	5.69	5.42	5.15	4.68	4.41	4.09
December	35.40	25.60	18.50	15.30	12.00	10.80	9.89	7.12	4.98	4.49	4.02	2.92	2.29	1.56
Minimum flow	15.2	9.7	6.1	4.6	3.2	2.8	2.4	1.5	1.1	1.0	0.7	0.4	0.2	0.1

Bosna River (flow in m^3/s)
1926-1974

Station : **Bojnik-uzvodna**
Longitude 43° 52' 10" E
Latitude 18° 17' 20" N
Chainage of statio 266.65 km
Drainage area 730.0 km^2
Datum of Gauge 481.94 m above MSL

River flow rates in m^3/s

Month	Cumulative Percentage %													
	0.1	1	5	10	20	25	30	50	70	75	80	90	95	99
January	90.3	64.0	45.4	37.0	28.5	25.7	23.3	16.5	11.8	10.6	9.5	7.4	6.2	5.0
February	74.9	57.5	43.0	36.6	29.7	27.3	25.4	19.0	14.0	12.7	11.4	8.5	6.4	3.6
March	71.4	57.6	47.7	42.6	36.8	34.8	32.8	28.1	21.6	20.2	18.8	14.7	12.0	7.3
April	93.8	74.2	59.2	51.8	43.8	41.2	38.8	31.2	24.6	22.9	21.3	17.3	14.3	9.7
May	73.5	60.4	49.4	44.2	38.1	36.0	34.3	27.9	22.4	20.9	19.5	16.6	12.5	7.3
June	45.0	36.6	29.9	26.7	22.9	21.5	20.4	16.5	13.1	12.0	11.2	8.6	6.9	3.6
July	33.0	26.2	20.8	18.3	15.4	14.4	13.5	10.8	8.5	7.8	7.1	5.6	4.6	2.8
August	26.5	20.4	15.8	13.6	11.2	10.4	9.7	7.5	5.6	5.2	4.7	3.6	2.8	1.6
September	32.7	24.8	19.0	16.2	13.3	12.2	11.4	8.6	6.36	5.8	5.2	3.9	3.0	1.7
October	62.8	46.6	34.3	28.9	22.9	20.8	19.2	14.0	9.9	8.8	7.8	5.4	4.0	2.1
November	85.4	64.7	49.0	41.9	32.5	31.2	28.8	21.5	15.9	14.2	12.5	9.6	7.2	3.8
December	98.0	70.7	51.4	42.8	34.0	30.8	28.1	21.4	16.0	14.8	13.5	11.1	9.9	8.4
Minimum flow	26.5	20.4	15.8	13.6	11.2	10.4	9.7	7.5	5.6	5.2	4.7	3.6	2.8	1.6

N . 5.2 TREATED EFFLUENT QUALITY TO SATISFY RIVER QUALITY STANDARDS

Treated effluent quality required to satisfy the Bosna River at Class III is calculated with the following assumptions:

a) Upstream of treated effluent discharge, Bosna River and Miljacka River are at the limiting values to satisfy Class II river quality standards.

b) Bosna River downstream of treated effluent discharge is are at the limiting values to satisfy Class III river quality standards.

c) Minimum flows for Miljacka River and Bosna River are 0.702 m^3/s and 3.67 m^3/s which are 95 percentile values.

d) WWTP discharge is 196,000 m^3/d in the year 2015

Bosna River - Upstream of WWTP Discharge
Class II

BOD_5	4 mg/L
COD	12 mg/L
SS	30 mg/L
Minimum flow	317,088 m^3/d
	3.67 m^3/s

Miljacka River - Upstream of WWTP Discharge
Class II

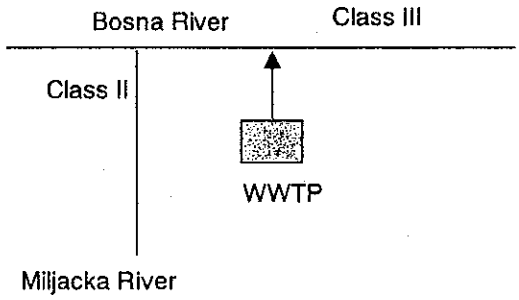
BOD_5	4 mg/L
COD	12 mg/L
SS	30 mg/L
Minimum flow	60,653 m^3/d
	0.702 m^3/s

Bosna River - Downstream of WWTP Discharge
Class III

BOD_5	7 mg/L
COD	20 mg/L
SS	80 mg/L
Flow	573,741 m^3/d
	6.6 m^3/s

Required WWTP Effluent

BOD_5	12.8 mg/L
COD	35.4 mg/L
SS	176.4 mg/L
Flow	196,000 m^3/d
	2.3 m^3/s



Therefore, WWTP effluent need to be below 12.8 mg/L of BOD_5 which is the limiting effluent parameter. Achieving this would require tertiary treatment and requires extensive process modification compared to the original design criteria which was 20 mg/L of BOD_5 achieved by secondary treatment.

Furthermore, as determined in the water quality survey carried out, there are several untreated discharges to Miljacka River which releases pollutant load prior to WWTP. This causes unpleasant visual perception of Miljacka River and odour of river within the Sarajevo City which is detrimental for the public opinion of sewerage works performance. Considering these, outright modification of treatment process to the tertiary treatment level to satisfy the river classification is not required. On the other hand, improvement of sewerage system to eliminate untreated

discharges should be carried out following the rehabilitation of WWTP. It is therefore concluded that the original effluent criteria of BOD5 at 20 mg/L and SS at 30 mg/L is satisfactory for rehabilitation of WWTP. This was agreed with ViK and the Ministry of Agriculture, Water Management and Forestry through written correspondence.

N.5.3 MINIMUM FLOW OF BOSNA RIVER BELOW WHICH RIVER QUALITY STANDARDS CANNOT BE SATISFIED WITH THE PROPOSED WWTP EFFLUENT QUALITY

Calculation is made with the assumptions shown below:

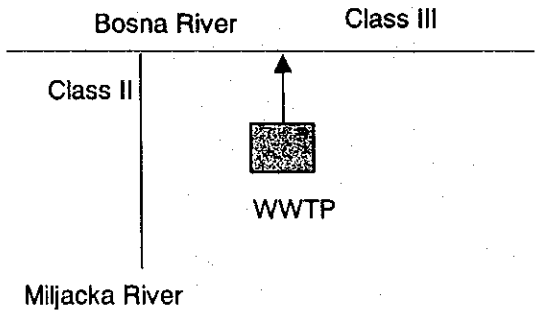
a) WWTP effluent quality is 20 mg/L BOD_5 and 30 mg/L SS

b) WWTP discharge is 196,000 m^3/d in the year 2015

Bosna River – Upstream of WWTP Discharge	
Class II	
BOD_5	4 mg/L
Minimum flow	849,333 m^3/d
	9.8 m^3/s

Bosna River – Downstream of WWTP Discharge	
Class III	
BOD_5	7 mg/L
Flow	1,045,333 m^3/d
	12.1 m^3/s

WWTP Effluent	
BOD_5	20 mg/L
SS	30 mg/L
Flow	196,000 m^3/d
	2.3 m^3/s



For Bosna River, return rate of flow below 9.8 m^3/s is estimated at approximately one in four years.

HEALTH-STATISTICAL DATA OF DISEASE, WHICH ARE BRING OVER WATER IN PREVIOUSLY PERIOD (20 – 30 YEARS)

Review of bowel infection disease movement and hydrical epidemy on current teritorry of Canton Sarajevo in above mentioned period.

Hydrical epidemy of Enterocolitis with 1200 contract on illness in 320 domestic houses was occur in Bistrik – municipality Old Town (Stari Grad).Epidemy take place from 1965 till 1972 year.Citizens used drinking water from source Studenac, in narrow pass at Bistrik stream'et. Bacteriological discovery of water didn't correspond to basis norms, because of Shigella isolation.

Grbavica citizens in 1971 year, 20 citizens which have beansurveyed be grieved on stomak pain and enterocolitis. From 20 person surveyed, by 10 persons echevicina coli was isolate. All persons surveyed be grieved (complained) on problems within waterworks and "Tilava" water.

At 1972 year, there was a problem with waterwork Kovačići.It was registrate 8 persons become ill from enterocolitis in Travnička, Ljubljanska and Nevesinjska street, SO Novo Sarajevo. Epidemic reasons are reduction and water deficiency (water shortage).

In 1972 year, appeared hydrical epidemy in Nedarići area in Juny. After summer pelting rain, septic tank flow over and that water poured into wells. Some about lenth of complete numbers of citizens get ill from Enterocolitis. In total get ill 38 persons in 16 domestic houses.Because vegetable was also flow over with epidemy, disease was extend till end of September.

In the same year hydrical epidemy Hepatitis "A" also appeared, that is virus infection which appeared in area Sokolje, SO Novi Grad, Buljakov Potok and Buča Potok. In that area get ill 78 children annd 114 older.

Hydrical well epidemy in area Lukavica, SO Novo Sarajevo, well bear by Serdarevići in 1971 year. Get ill 18 members of Sračevič family. Diagnose – Enterocolitis acuta.

Hydrical Enterocolitis epidemy also appeared in vilage Donji Kotorac, SO Ilida, with 20 disease persons in 1980, at the same year in vilage Mladice it was registrated 15 disease peersons from the same type of disease, students from department in Vojkovići, because ill from Hephatitis at the same year, it was surveyed in 20 domestic houses. At vilage Butmir in 1971, become ill 80 persons from Paratyphuse, 1972 in the same year 15 persons from Hepatitis disease, 38 persons from Enterocolitis disease. In vilage Rakovica from 1979 till 1982 became ill 120 persons from Hepatitis disease. Water facilities in Ruhotina. Kakrinje and Blažuj cross road have been improved sanitary.

In Hrasnica I and II and school that is belong there since 1981 till 1983 on the Bunički brook side get ill a few tenth of childrens from Hepatitis virus.

We made analysis of bowel infection disease specially number of diseased persons from Enterocolitis and Hepatitis "A" from 1980 till 1985. That was pre-olimpic year. See table 1a.In that table you can see that in municipality Novo Sarajevo and Novi Grad, specially in areas Buljakov Potok, Sokolje and Adem buća appeared epidemy Hepatitis "A", caused by water shortage. These epidemys was spreading by contact.

Besides Hepatitis and Enterocolitis, Dysenteria were increased, the same as after bowel infection. In a line of streets Ilidjanska and Djemala Bijedića, reconstruction of collector for waste water have been in procedure, the same in street 25th May. A lot of local comunities (LC) are pronounced as endem LC, as are Nedarići, Novi Grad, Butmir, Sokolovići and Blažuj cross road, Rakovica (Gladno polje, Center of Yugoslavia and school Gliša Janković) – SO Ilida, same areas at Hadići municipality, the same as vilage Svrake in municipality Vogošća.

In LC Stup, reconstruction of collector of waste water was construced for collecting of waste water in direction to area at city airport to Stup.
Table 1b – if we are looking sanitation inn 4 municipalities (Ilida, Vogošća, Hadići and Ilijaš), in period from 1980 till 1985 in the frame of water supplying, the worst one was in SO Ilida, where was 142 case of disease registrated.
In period from 1986 till 1990 situation with Enterocolitis and other bowel disease, have been rapidlyproved, because of infrastructure construction, which yoou can see in table 2a, which is focusing on narrow part of city in those 5 years.
But, it is registrated one hydrical epidemy on waterwork Gornji Miljevići. By 4 persons which are used water from local waterworks, it was isolate Echevicia coli, and by 2 person Shigella.
Table 2b showed situation of bowel disease on broadly areas of city (Ilida, Vogošća, Hadići and Ilijaš) in period from 1986 till 1991, and in those places, situation in Ilida and Vogošća is much more difficult, according to this problem, than in municipality Hadići and Ilijaš. It is already known that Hadići municipality has a problem with water supplying and bowel infections in dry period of summer, because of level declining at underground water in local waterworks, and chlorination units irregularly functioned which shaping a risk for massive disease.
In Hadići municipality at the end of summer 1987, in vilages Ljubovići and Lokve, reservoir was completely polluted and it was registrated more tenth ill persons from Hepatitis disease.
Movement of bowel disease in the war period, from 1992 till 1996, see table 3a. Situation on narrow area of Sarajevo city is as following:
on municipality Novi Grad the number of Enterocolitis disease is increased.Enterocolitis is one of the greatest disease of bowel infection disease (1131 case in 1992) and (2994 cases in 1995). On municipality Novo Sarajevo in period from 1993 till 1995, the number of persons infected by Enterocolitis disease were decreased from 2574 to 1370 cases. On municipality Centar in period of 1992 it was registrated 1575 cases of Enterocolitis disease and in 1993 – 1206 cases. Municipality Stari Grad in period from 1992 to 1993 had number of Enterocolitis disease cases from 1093 to 1348.
The same indications are consist also for Disenteria, Hepatitis "A" and other bowel infection diseases.
Inundation (flood) and bad disposition of waste material are not the only cause of disease, than using of inadequate water for drinking.On latitude municipalities of city Sarajevo (Ilida, Vogošća, Hadići and Ilijaš) in a lot of war years, we don't have precise registrated data. See table 3b.
In after war period from 1997 to 1999 (table 4a), situation with bowel diseases is improving nastily, diseases caused by water supplying are decreased, but also,there was a flood in Sarajevo city. For that period the moust atractive are respiratorical diseases, expressly in the city and in Canton Sarajevo. Those are pre-war diseases, and bowel diseases are in decreasing. The same situation is on 4 latitude municipalities of the city (see table 4b), but on municipality Hadići is registrated 108 cases of bowel infection disease.

Sarajevo, March 30 1999

CHIEF OF SERVICE

Prim. Dr. Fahrudin Čorović

N.7. Water Low Regarding the Sludge Disposal

SLUDGE ANALYSIS

A. FBiH Laws

1. No laws directly concerning or mentioning "sludge" were found; however, as reflected in no. 3. below, the 1998 FBiH Water Law does contain several Articles which address disposal and re-use of sludge-related items, i.e., "waste burden" and "waste substance.".

2. Additionally, according to the laws of the Federation of Bosnia and Herzegovina (FBiH), the federal Ministry of Physical Planning and the Environment and the federal Ministry of Agriculture, Water Management and Forestry, are in charge of waste management. The Law on Physical Planning [a pre-FBiH, former Socialist Republic of Bosnia and Herzegovina law which remains in effect since it is not inconsistent with the Constitution of Bosnia and Herzegovina - see Annex II, Section 2. to Annex 4 to The General Framework Agreement for Peace in Bosnia and Herzegovina] sets the legal framework for waste management. OHR Legal Environmental Department does not have an English-language version of this law and is therefore unable to determine if it contains any sludge-related matters.

3. The 1998 FBiH Water Law states in relevant part as follows:

Article 27

...

Waterworks facilities which are used for water protection of waste water of the villages and industry on the territory of the Federation and another country, two or more cantons, respectively (sewers for receiving and transport of the waste water waste water treatment plant, outlets in the recipient and **landfills for waste substance for waste water treatment**) are of importance to the Federation.

Article 44

Ministry issues an approval for the following:

...

16. construction of facilities for disposal or storage of solid and liquid **waste** and **waste burden and landfills**.

Article 49

...

Permission is issued for water usage, discharge of impounding reservoirs, discharge of **waste** water and for **disposal or discharge of hazardous and harmful matters on public water resources, agriculture and forest land** and in the atmosphere
(hereinafter: discharge of **waster** water).

Article 88

In order to maintain river beds and water streams banks, coastal sea, flumes of lateral and drainage channels, flumes and banks of the artificial impounding reservoirs and surface storage, as well as dams and plants, it is in particular [forbidden]:

...

2. to cast into water streams, lakes, seas, impounding reservoirs and into surface storage, as well as dump at the water streams banks, lakes, coastal sea, impounding reservoirs and surface storage the following: stone, earth, overburden and other solid and liquid waste and material;

4. Summary: Landfills for waste substances [sludge] from waste water treatment are of importance to the Federation (Article 27).

a. Sludge Disposal: The 1998 Water Law requires Ministry approval for construction of facilities for disposal of solid waste and waste burden [sludge] (Article 44).

b. Sludge Re-Use: The 1998 Water Law requires permission be issued for disposal of hazardous and harmful matters [sludge?] on agriculture land.

B. EU Regulations

[NOTE: European Union initiatives in the area of sludge fall under the framework for action in the field of water policy. The sewerage sludge directive (86/278/EEC), no. 1. below, is a piece of EU legislation which, together with national or local legislation, would make up a baseline measure for sludge. It would be one compulsory element of a program of measures for the protection of water. The directive lays down minimum limit values for content of heavy metals and periods of application for the purpose of hygienic safeguards. In the absence of controlling FBiH legislation, it is recommended this directive be utilized as a basic measure to be followed. Use outside agriculture is not at present regulated at an EU level - see no. 3 below. FBiH has not currently implemented EU regulations.]

1. Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture

[states in relevant part as follows]

...

Article 1

The purpose of this Directive is to regulate the use of sewage **sludge** in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, thereby encouraging the correct use of such sewage **sludge**.

Article 2

For the purposes of this Directive:

(a)'**sludge**' means:

(i)residual **sludge** from sewage plants treating domestic or urban waste waters and from other sewage plants treating waste waters of a composition similar to domestic and urban waste waters;

(ii)residual **sludge** from septic tanks and other similar installations for the treatment of sewage;

(iii)residual **sludge** from sewage plants other than those referred to in (i) and (ii);

(b)'treated **sludge**' means:

sludge which has undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use;

(c)'agriculture' means:
the growing of all types of commercial food crops, including for stock-rearing purposes;
(d)'use' means:
the spreading of **sludge** on the soil or any other application of **sludge** on and in the soil.

Article 3
1. The **sludge** referred to in Article 2 (a) (i) may only be used in agriculture in accordance with this Directive.
2. Without prejudice to Directives 75/442/EEC and 78/319/EEC:
-the **sludge** referred to in Article 2 (a) (ii) may be used in agriculture subject to any conditions that the Member State concerned may deem necessary for the protection of human health and the environment,
-the **sludge** referred to in Article 2 (a) (iii) may be used in agriculture only if its use is regulated by the Member State concerned.
...
Article 5
Without prejudice to Article 12:
1.Member States shall prohibit the use of **sludge** where the concentration of one or more heavy metals in the soil exceeds the limit values which they lay down in accordance with Annex I A and shall take the necessary steps to ensure that those limit values are not exceeded as a result of the use of **sludge**.
2.Member States shall regulate the use of **sludge** in such a way that the accumulation of heavy metals in the soil does not lead to the limit values referred to in paragraph 1 being exceeded. To achieve this, they shall apply one or other of the procedures provided for in (a) and (b) below:
(a)Member States shall lay down the maximum quantities of **sludge** expressed in tonnes of dry matter which may be applied to the soil per unit of area per year while observing the limit values for heavy metal concentration in **sludge** which they lay down in accordance with Annex I B; or (b)Member States shall ensure observance of the limit values for the quantities of metals introduced into the soil per unit of area and unit of time as set out in Annex I C.

Article 6
Without prejudice to Article 7:
(a)**sludge** shall be treated before being used in agriculture. Member States may nevertheless authorize, under conditions to be laid down by them, the use of untreated **sludge** if it is injected or worked into the soil;
(b)sewage-**sludge** producers shall regularly provide users with all the information referred to in Annex II A.

Article 7
Member States shall prohibit the use of **sludge** or the supply of **sludge** for use on:
(a)grassland or forage crops if the grassland is to be grazed or the forage crops to be harvested before a certain period has elapsed. This period, which shall be set by the Member States taking particular account of their geographical and climatic situation, shall under no circumstances be less than three weeks;
(b)soil in which fruit and vegetable crops are growing, with the exception of fruit trees;
(c)ground intended for the cultivation of fruit and vegetable crops which are normally in direct contact with the soil and normally eaten raw, for a period of 10 months preceding the harvest of the crops and during the harvest itself.

Article 8
The following rules shall be observed when using **sludge**:
-the **sludge** shall be used in such a way that account is taken of the nutrient needs of the plants and that the quality of the soil and of the surface and ground water is not impaired,
-where **sludge** is used on soils of which the pH is below 6, Member States shall take into account the increased mobility and availability to the crop of heavy metals and shall, if necessary, reduce the limit values they have laid down in accordance with Annex I A.

Article 9
Sludge and soil on which it is used shall be analyzed as outlined in Annexes II A and II B.
The reference methods for sampling and analysis are indicated in Annex II C.

Article 10
1. Member States shall ensure that up-to-date records are kept, which register:
(a)the quantities of **sludge** produced and the quantities supplied for use in agriculture;
(b)the composition and properties of the **sludge** in relation to the parameters referred to in Annex II A;
(c)the type of treatment carried out, as defined in Article 2 (b);
(d)the names and addresses of the recipients of the **sludge** and the place where the **sludge** is to be used.
2. The records shall be available to the competent authorities and shall provide a basis for the consolidated report referred to in Article 17.
3. Information on the methods of treatment and the results of the analyses shall be released upon request to the competent authorities.

Article 11
Member States may exempt from Article 6 (b) and Article 10 (1) (b), (c) and (d) and paragraph 2, **sludge** from sewage treatment plants with a treatment capacity below 300 kg BOD5 per day, corresponding to 5 000 person equivalents, which are designed primarily for the treatment of domestic waste water.

Article 12
Where conditions so demand, Member States may take more stringent measures than those provided for in this Directive.
Any decision of this nature shall be communicated to the Commission in accordance with existing agreements.
...
ANNEX II B
SOIL ANALYSIS 1.Whenever **sludge** other than **sludge** from the treatment plants referred to in Article 11 is used, Member States must first ensure that the heavy metal content of the soil does not exceed the limit values laid down in accordance with Annex IA. For this purpose, Member States shall decide what analyses to carry out, taking account of available scientific data on soil characteristics and homogeneity.
2.Member States shall decide on the frequency of further analyses, taking account of the metal content of the soil prior to the use of **sludge**, the quantity and composition of the **sludge** used and any other relevant factors.
3.Analysis should cover the following parameters:
-pH,
-cadmium, copper, nickel, lead, zinc, mercury and chromium.

ANNEX II C
SAMPLING AND ANALYSIS METHODS 1.Soil sampling The representative soil samples for analysis should normally be made up by mixing together 25 core samples taken over an area not exceeding 5 hectares which is farmed for the same purpose.
The samples must be taken to a depth of 25 cm unless the depth of the surface soil is less than that value; however, the sampling depth in the latter case must not be less than 10 cm.
2.Sludge sampling Sludge must be sampled after processing, but before delivery to the user, and should be representative of the sludge production.
3.Methods of analysis. Analysis for heavy metals must be carried out following strong acid digestion. The reference method of analysis must be that of atomic absorption spectrometry and the limit of detection for each metal should be no greater than 10 % of the appropriate limit value.

2. Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

[states in relevant part as follows:]
...

Whereas industrial waste water entering collecting systems as well as the discharge of waste water and disposal of **sludge** from urban waste water treatment plants should be subject to general rules or regulations and/or specific authorizations;
...
Whereas the recycling of **sludge** arising from waste water treatment should be encouraged; whereas the disposal of **sludge** to surface waters should be phased out;
Whereas it is necessary to monitor treatment plants, receiving waters and the disposal of **sludge** to ensure that the environment is protected from the adverse effects of the discharge of waste waters;
Whereas it is important to ensure that information on the disposal of waste water and **sludge** is made available to the public in the form of periodic reports;
...
HAS ADOPTED THIS DIRECTIVE:
...
Article 14
1. **Sludge** arising from waste water treatment shall be re-used whenever appropriate. Disposal routes shall minimize the adverse effects on the environment.
2. Competent authorities or appropriate bodies shall ensure that before 31 December 1998 the disposal of **sludge** from urban waste water treatment plants is subject to general rules or registration or authorization.
3. Member States shall ensure that by 31 December 1998 the disposal of **sludge** to surface waters by dumping from ships, by discharge from pipelines or by other means is phased out.
4. Until the elimination of the forms of disposal mentioned in paragraph 3, Member States shall ensure that the total amount of toxic, persistent or bioaccumulable materials in **sludge** disposed of to surface waters is licensed for disposal and progressively reduced.

Article 15
1. Competent authorities or appropriate bodies shall monitor:
...
- amounts and composition of **sludges** disposed of to surface waters.
...
ANNEX I

REQUIREMENTS FOR URBAN WASTE WATER
...
C. Industrial waste water
Industrial waste water entering collecting systems and urban waste water treatment plants shall be subject to such pre-treatment as is required in order to:
...
- ensure that the operation of the waste water treatment plant and the treatment of **sludge** are not impeded,
...
- ensure that **sludge** can be disposed of safely in an environmentally acceptable manner.

3. Proposal for a European Parliament and Council Decision on an action programme for integrated groundwater protection and management (96/C 355/01):

[states in relevant part as follows]
...

ACTION LINE 3.4 - ENVIRONMENTAL CHALLENGES FROM USE OF SEWAGE **SLUDGE**
Following the establishing of treatment plants for urban waste, water sewage **sludge** is produced in increasing amounts. In order to bring the contents of the **sludge** to good use or to dispose of it, a practice of applying sewage **sludge** on agricultural land has developed in some Member States. In this way the nitrate and phosphate content may be recycled. Control of pollution from urban waste water, septic tanks, leaking sewers, etc. is dealt with in action line 4 on point sources.
Sewage **sludge** may contain high concentrations of dangerous substances and heavy metals, and the concentration of nitrate and phosphate varies considerably for different types of **sludge**, thereby making the **sludge** less reliable than chemical or organic fertilizers. Inappropriate application may create problems with pollution of groundwater and surface water and of soil similar to the problems encountered with use of other fertilizers. Problems of hygiene may arise thereby potentially threatening groundwater and surface water as well as the quality of the crops themselves. Smell also could pose problems, for example, near built-up areas and in public forests.
Use in agriculture is regulated by **Directive 86/278/EEC of 12 June 1986** on the protection of the environment, and in particular of the soil, when sewage **sludge** is used in agriculture (). The Directive lays down minimum limit values for content of heavy metals and periods of application for the purpose of hygienic safeguards. Some Member States have laid down more strict limit values than the Directive and limit values have been fixed for additional dangerous compounds or heavy metals. Some Member States also require that spreading of **sludge** on land must serve a purpose such as fertilization or soil improvement and not simply be used as a way of disposing of waste.

Use outside agriculture is not at present regulated at Community level.
Objective
The objective is to avoid negative effects on groundwater from the use of sewage **sludge** in order to allow continued or increased recycling of organic matter in **sludge** on agricultural and other appropriate land.
Action at Member State level
- Possibilities for further environmentally sound use of **sludge** on land should be examined.
- A good and constant quality of **sludge** not exceeding the limit values for heavy metals and other contaminants should be ensured, thus allowing for the use of sewage **sludge** on agricultural land for improving the texture of the soil as well as a fertilizer. This should make recycling of nutrients possible in an environmentally sound way. Nutrients in the **sludge** should be accounted for in the overall nutrient balance.
- Limit values and standards for content of polluting substances and nutrients in sewage **sludge** should be reviewed as appropriate with a view to development of standards for other relevant compounds where such are not presently established.
- General rules should be established for the spreading of **sludge**, including appropriate restrictions on application within protection zones with groundwater resources intended for drinking water purposes.
Action at Community level - Community legislation should be reviewed with a view to establishing and/or implementing measures to minimize discharge of dangerous substances and heavy metals into sewage systems from households and industrial facilities.
- Limit values of Directive 86/278/EEC on use of sewage **sludge** should be reviewed with a view to scientific updating.
- Standards for characterization methods for sewage **sludge** should be developed. The Commission should follow the studies initiated by the European Standardization Organization (CEN) scheduled to be completed by 1998.

Note on the Meeting with "RAD" on Wastewater Sludge Disposal

24 June 1999

Mr. Selim Babic, Director of public hygiene

Mr. Enes Filipovic, Director of sector for economy and legal affairs

Mr. Jasmin, WWTP Superintendent

Mr. Kaoru Suzuki, Team Leader, JICA Study Team

Mr. S. Kugaprasatham, JICA Study Team, Water Quality/Environment

1. RAD requires information on quantity and quality of sludge to be disposed from ViK/JICA Study Team. Would like to know the possibility of sludge for use as soil cover in landfill, and composting with household municipal waste since RAD plans to reduce the organic matter to be disposed in the landfill. (Source of daily cover at present is the construction debris from the city which is available in excess.)
   -approximately 160 tons with a volume of 130 m^3 with a solids content of 25% in the year 2015. (RAD considers that this is a significant amount which will reduce the life of landfill.) However, possibility of agricultural use will be investigated once the WWTP is functional which may result in reduced quantities for disposal. Necessary to provide yearly sludge quantities to RAD.
   -will provide typical information of anaerobically digested, dewatered sludge
   -composting with municipal refuse is possible but needs investigation.
   -use as daily soil cover will also require chemical treatment which needs investigation.
2. Landfill is being transformed to a sanitary landfill to meet EU regulations. Organic matter is planned to be reduced. Leachate and stormwater are collected separately for treatment and disposal.
   - RAD asked the possibility of connecting to Rajlovac collector to discharge leachate.
     - technically, pre-treatment has to be provided to the level of industrial discharge standards for accepting leachate to WWTP.
     - For including the collector sewer construction to the WWTP project, RAD has to contact with the MOAWWF or VIK.
3. Once the quality of sludge is known RAD can make a decision on the acceptability of sludge. Basically, inert, radioactive or toxic materials are not acceptable. Organic matter has to be reduced (to what level ?).
4. Charge
   Currently, one truck is charged 16.5 KM for garbage and 90 KM per truck for private. However, in the future charges will be increased to an economical value

which is currently estimated at 90 KM/ton. RAD concerned that illegal dumping will increase if the charge is not socially acceptable.

5. RAD has truck with capacities of 15to 20 m^3 and 4.5 to 7 m^3 which can be provided for transporting sludge.
6. RAD will reply in writing to the Team's request for information.
7. During war, several thousand tonnes of garbage were deposited at an adhoc site which was cleared later by the municipalities. Probably, some disease such as yellow fever was prevalent due to that adhoc site.

Request for Information to RAD on Solid Waste Disposal Site

1. Description of the disposal site (area, capacity, groundwater level, elevation, soil type, source of daily cover)
2. Measured and projected solid waste quantity (1990 – 2015)
3. Any limitation for accepting digested, dewatered sludge (quality)
4. Charge for disposal of sludge
5. Will RAD (or private) provide trucks for transportation and costs at present
6. Capacity of truck/containers (limitation of weighing platform, length, width, weight)
7. Quantity and quality of leachate
8. Size of the holding tanks for leachate and stormwater and future plan for treatment
9. Detail of any environmental assessment performed for the site
10. Proposed improvements for the site

Subject: Quality of Sludge Cake for Disposal

Solids in wastewater settled in the primary sedimentation tank and activated sludge settled in the secondary sedimentation tank are the source of wastewater sludge. This sludge is mixed and anaerobically digested and dewatered to obtain sludge cake for disposal. This process is designed to obtain sludge cake of approximately 25% of solids and 75% of water. Sludge cake will contain stabilized organic matter. Since the WWTP is not functioning, quality of sludge cake obtained from a publication is provided for information. At that time of the publication industries were functioning.

To control toxic materials, such as heavy metals, stringent industrial effluent standards for discharge in to public sewerage system is expected to be implemented. When the WWTP is re-commissioned, WWTP sludge cake can be monitored for controlling toxic materials.

Currently, there are no standards for sludge disposal in BiH. EU regulations deal with the agricultural reuse of sludge. There are no EC standards regarding disposal of sludge to landfills on heavy metals. Following table compares the content of sludge cake in 1988 which is favorable for agricultural reuse by EU standards, which can be considered favorable for landfill disposal as well.

Unit : mg/kg dry weight

Parameter	Sludge Cake (1987)*1	EC Directive*2 86/278/EEC Appendix 1B
Zinc (Zn)	2,956	2,500 – 4,000
Manganese (Mn)	436	
Lead (Pb)	98	75 - 1200
Copper (Cu)	248	1,000 – 1,750
Cadmium (Cd)	5.5	20 - 40
Nickel (Ni)	94	300 - 400
Chromium (Cr)	56	1,000 – 1,500
Cobalt (Co)	12	
Mercury (Hg)		16 - 25

*1 – Distribucija teksih metala izmedju cvrste I tecne faze muljeva postojenja za otpadne vode u sarajevu – Dr. Esma Velagic Habul & Zlatko Hofman, average of three determinations.

*2 - These are sludge boundary values for agricultural reuse.

However, implementation of agricultural reuse will require further investigation and control of soil characteristics, crops to be used etc. Agricultural reuse, co-composting with municipal refuse etc. need to be investigated to reduce the volume for disposal.

Characteristics of Sludge Cake*1

Parameter	Value
Solids content (105°C)	25.0 %
Volatile Solids (550°C)	44.6 %
COD, mg O_2/L	173,900
BOD_5, mg O_2/L	62,500

*1 – Distribucija teksih metala izmedju cvrste I tecne faze muljeva postojenja za otpadne vode u sarajevu – Dr. Esma Velagic Habul & Zlatko Hofman, average of three determinations.

DISTRIBUCIJA TEŠKIH METALA IZMEDJU ČVRSTE I TEČNE FAZE MULJEVA POSTROJENJA ZA OTPADNE VODE U SARAJEVU

Dr.Esma Velagić Habul,Poljoprivredni fakultet Sarajevo
Zlatko Hofman,dipl.ing.Zavod za Vodoprivredu SR BiH

Uzorci muljeva i vode sa postrojenja za prečišćavanje gradskih otpadnih voda u Sarajevu,uzeti kao trenutni uzorci u intervalima od 15 dana (zimski period) analizirani su na sadržaj teških metala (Zn,Mn,Cu,Ni,Cr, Co,Cd i Pb) s ciljem da se utvrdi njihova distribucija izmedju tečne i čvrste faze tokom procesa.Analizirani su uzorci iz kolektora,influenta,primarnog taložnika, zgušnjivača,digestora,homogenizatora,efluenta i muljnog kolača. Utvrdjeno je da se metali dominantno vežu za čvrstu,organsku fazu i date su aproksimativne vrijednosti za količine metala koje napuštaju postrojenje sa tečnom fazom. (efluentom).

Postrojenje za prečišćavanje gradskih otpadnih voda u Sarajevu,dnevno daje oko 160m^3 otpadnog mulja (Drače Z.,1984)Prema projektu,nakon završene obrade muljni kolač se transportuje u kontejnere i dalje na gradsku deponiju. Od 1983 godine vrše se ispitivanja mogućnosti primjene ovog mulja kao organskog djubriva na poljoprivredne površine. U svijetu ovakva praksa ima dužu tradiciju (V.Britanija,Francuska,Švajcarska,SAD,Njemačka). Valorizaciji mulja kao sekundarnog proizvoda doprinose sadržaj organske materije (oko 40% od SM) azota (oko 2%) i fosfora (0,8-1%) čija primjena na zemljište značajno poboljšava njegova fizičko-hemijska svojstva. Današnji,svjetski,trend unošenja sve većih količina organskih djubriva u zemljište,povećat će značajnost korištenja otpadnog mulja u poljoprivredi.

Medjutim,svjetska literatura upozorava da je korištenje mulja na ovakav način praćeno odredjenim negativnim efektima. Ti efekti su prije svega mogućnost pojave patogenih mikroorganizama u zemljištu i na biljkama, povećane količine teških metala u zemljištu, što putem lanca ishrane može ugroziti zdravlje životinja i ljudi. Pored toga postoji opasnost od ispiranja teških metala

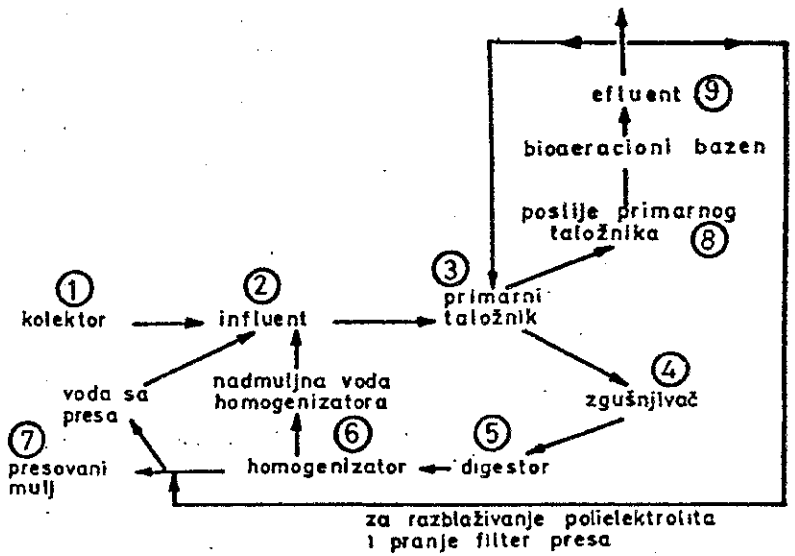
u podzemne vode tokom vremena.

Prateći promjene koncentracija teških metala u muljnom kolaču sa postrojenja u Sarajevu (Velagić-Habul,Šaćiragić,Hofman,1987) već smo utvrdili da su za sada te koncentracije na nivou onih objavljenih za najveći broj slično dobijenih muljeva. Medjutim zanimalo nas je gdje u tehnološkom procesu dolazi do povećane distribucije teških metala u čvrstu fazu,odnosno koja je to faza procesa, na primjeru sarajevskog postrojenja, u kojoj dolazi do značajno izražene distribucije, kako bi se eventualno moglo uticati na usmjeravanje uspostavljene ravnoteže. Drugi aspekt ovoga bi bio koliko osobodjen od teških metala efluent napušta postrojenje za prečišćavanje otpadnih voda.

Metodika rada

Imajući na umu tok procesa prečišćavanja vode, uzorci su uzimani na mjestima karakterističnim za odredjene faze (shema 1):

Shema 1.: Linija mulja i vode sa naznačenim mjestima uzimanja uzoraka



Uzimani su trenutni uzorci u tri vremenska intervala:13 januar,1.februar i 17.februar (zimski period).Razlike u osnovnim karakteristikama mulja i vode (tabele 1.i 2.) rezultat su trenutačnog stanja tehnološkog procesa na postrojenju. Tokom zimskog perioda javljaju se poteškoće u procesu digestije usljed hladjenja a i česti su kvarovi na kompresorima što ima za posljedicu slabije miješanje

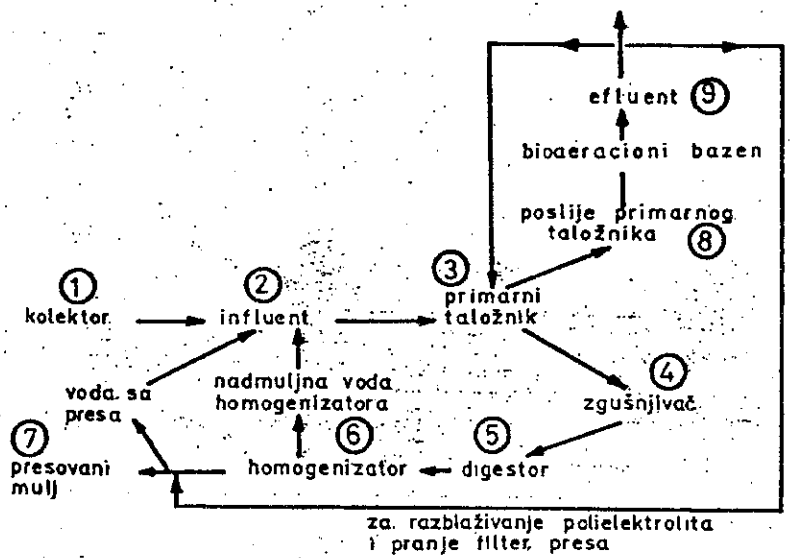
u podzemne vode tokom vremena.

Prateći promjene koncentracija teških metala u muljnom kolaču sa postrojenja u Sarajevu (Velagić-Habul,Šaćiragić,Hofman,1987) već smo utvrdili da su za sada te koncentracije na nivou onih objavljenih za najveći broj slično dobijenih muljeva. Medjutim zanimalo nas je gdje u tehnološkom procesu dolazi do povećane distribucije teških metala u čvrstu fazu,odnosno koja je to faza procesa, na primjeru sarajevskog postrojenja, u kojoj dolazi do značajno izražene distribucije, kako bi se eventualno moglo uticati na usmjeravanje uspostavljene ravnoteže. Drugi aspekt ovoga bi bio koliko osobodjen od teških metala efluent napušta postrojenje za prečišćavanje otpadnih voda.

Metodika rada

Imajući na umu tok procesa prečišćavanja vode, uzorci su uzimani na mjestima karakterističnim za odredjene faze (shema 1):

Shema 1.: Linija mulja i vode sa naznačenim mjestima uzimanja uzoraka



Uzimani su trenutni uzorci u tri vremenska intervala:13 januar,1.februar i 17.februar (zimski period).Razlike u osnovnim karakteristikama mulja i vode (tabele 1.i 2.) rezultat su trenutačnog stanja tehnološkog procesa na postrojenju. Tokom zimskog perioda javljaju se poteškoće u procesu digestije usljed hladjenja a i česti su kvarovi na kompresorima što ima za posljedicu slabije miješanje

Tabela 1.
OPCE KARAKTERISTIKE MULJEVA

	Mulj.prim. taložnika.	Mulj zgušnjiv.	Mulj digest.	Mulj Homogeni	Muljni kolač
13.01.1988					
(1) Isparljivi ostatak (105°C) g / l	27,74	30,06	34,28	36,54	25,4 %SM
(2) Volatilna materija (550°C) g / l	15,06	15,40	16,94	17,02	44,8 %
(3) HPK (mgO_2/l)	25.600	25.600	28.000	22.400	184.000
(4) BPK_5(mgO_2/l)	11.000	15.000	11.000	8.500	102.5000
1.2.1988					
Isparljivi ostatak (105°C) g / l	49,62	58,24	45,32	55,82	24,5 %
Volatilna materija (550°C) g / l	24,32	28,92	25,20	28,06	45,0 %
COD HPK (mgO_2/l)	45.120	49.220	26.880	40.960	168.000
BOD BPK_5(mgO_2/l)	10.400	13.000	7.330	6.600	53.000
17.2.1988					
Isparvljivi ostatak (105°C) g / l	17,59	69,52	47,32	89,26	25,0 %
Volatilna materija (550°C) g / l	9,43	37,86	20,52	38,25	44,0 %
COD HPK (mgO_2/l)	16.480	55.360	32.320	64.640	169.600
BOD BPK_5 (mgO_2/l)	5.400	14.800	7.500	8.600	32.000

Tabela 2.

OPĆE KARAKTERISTIKE VODE

	Kolektor	Influent	Poslije prim. taložnika	Efluent
13.1.1988				
(1) Isparljivi ostatak (105°C) mg/l	90	3.320	48	34
(2) Volatilna materija (550°) mg/l	77	1.770	37	26
(3) HPK (mgO_2/l)	111	1.762	63	29
(4) BPK_5 (mgO_2/l)	35	365	82	65
1.2.1988				
Isparljivi ostatak (105°C) mg/l	-	825	105	41
Volatilna materija (550°C) mg/l	-	400	70	24
HPK (mgO_2/l)	-	704	134	35
BPK_5 (mgO_2/l)	-	260	112	22
17.2.1988				
Isparljivi ostatak (105°C) mg/l	225	378	44	32
Volatilna materija (550°C) mg/l	200	252	32	20
HPK (mgO_2/l)	316	520	84	54
BPK_5 (mgO_2/l)	200	250	54	13

N - 30

muljeva i filtraciju. Upravo je ovo bilo karakteristično za prvi termin uzimanja uzoraka. Drugi termin uzimanja uzoraka je pratio prebacivanje mulja iz digestora 1 u digestor 2. pa kao posljedicu toga u trećem terminu dobijeni su gušći i više mineralizovani muljevi.

Uzorci sa linije mulja su analizirani kao cjeloviti a istodobno su centrifugiranjem i filtracijom dijeljeni na talog i supernatant. Centrifugiranje je vršeno na 3000 ob./min. 10 minuta, a filtracija membran filterima 0,45 μ.

Sadržaj Zn,Mn,Cd,Co,Cu,Ni,Pb i Cr odredjen je metodom atomske apsorpcione spektorskopije na aparatu Pay Unicam 800. Uzorci vode su radjeni direktno a muljevi su najprije spaljeni kombinacijom HNO_3 i $HClO_4$.

REZULTATI I DISKUSIJA

Rezultati analiza prikazani su u tabelama 3 i 4.

Treba naglasiti da u zimskom periodu (periodu ispitivanja) postoji enormna opterećenost otpadne vode na ulazu u postrojenje (tabela 1. i 2.) što je posljedica otežanog rada pogona filtracije (zaledjivanje pojedinih dijelova sistema,česti kvarovi na pumpama i sl.). Zbog toga dolazi do nagomilavanja mulja u sistemu. Drugim riječima jedna ista količina mulja jednostavno kruži linijom mulja adsorbirajući na micelama mulja sve veće količine teških metala. Takvu situaciju imamo upravo u drugom i trećem terminu uzimanja uzoraka. Medjutim,uprkos tome,tabele pokazuju da se i u ovako otežanim uslovima odvijanja procesa,teški metali već nakon primarnog taloženja vežu za čvrstu,organsku fazu. Prateći dalje liniju mulja,uočavamo da se koncentracije metala,izražene na sadržaj suhe tvari,gotovo pravilno održavaju na istom nivou u muljevima sve do kraja procesa. Odnosno,sadržaj teških metala u liniji vode je veoma mali i u efluentu zadovoljava standarde. Ako bismo željeli dati aproksimativne vrijednosti za distribuciju metala izmedju čvrste i tečne faze onda su one slijedeće: za Zn 0,4% od ukupne količine ostaje u vodi,,Mn 0,01%, Pb 0,01,Co 0,05%,Ni 0,02,CrO,12,Cu 0,03 i za Cd 0,00%.

Output - water

Rezultati pokazuju da se već u prvoj fazi prerade otpadne vode,teški metali izdvajaju u mulj i da to koncentrisanje može varirati zavisno o količine suhe materije u mulju. Drugim riječima primjenjen na zemljište mulje će uvijek biti moguć izvor toksičnih koncentracija teških metala u ovom mediju.

Tabela 3.a.

SADRZAJ TESKIH METALA - LINIJA MULJA

Termin	Zn				Mn			
	A.	B.	C.	D.	A.	B.	C.	D.
(1.1) Mulj primarnog taložnika								
1.	55,02	0,23	347,60	2.094,40	10,42	0,12	61,70	396,65
2.	112,90	0,53	340,3	2.316,30	19,02	0,18	59,23	390,20
3.	17,72	0,32	269,34	723,10	5,20	0,10	49,42	295,60
(2.1.) Mulj zgušnjivača								
1.	51,64	0,21	352,48	1.852,20	9,45	310	65,22	338,95
2.	130,38	0,29	438,84	2.211,70	23,45	480	59,99	397,80
3.	109,02	0,17	388,50	1.587,10	20,85	500	54,10	303,50
(3.1) Mulj digestora								
1.	65,34	0,03	355,08	2.036,10	11,87	60	65,26	369,90
2.	125,72	0,59	218,87	2.818,20	20,95	120	43,31	469,60
3.	90,44	0,17	310,30	6.675,90	16,22	90	61,02	348,90
(4.1) Mulj homogenizatora								
1.	69,91	0,05	379,40	1.963,20	14,38	10	60,81	403,80
2.	123,89	0,37	388,40	2.206,00	23,62	220	14,88	420,60
3.	157,75	0,59	413,55	1.827,5	30,64	150	76,84	354,90
(5.1) Muljni kolač								
1.				2.969,0				409,34
2.				2.772,46				410,70
3.				3.127,25				491,90

N-31

Tabela 3.b.

SADRZAJ TESKIH METALA - LINIJA MULJA

Termin	Pb				Cu			
	A.	B.	C.	D.	A.	B.	C.	D.
(1.1) Mulj primarnog taložnika								
1.	4,55	-	22,12	173,2	7,83	0,18	45,14	298,06
2.	5,28	0,03	15,10	107,3	13,85	0,06	40,07	284,24
3.	3,70	0,04	24,21	210,3	3,60	0,23	33,95	204,66
(2.1) Mulj zgušnjivača								
1.	5,83	0,02	23,68	209,10	7,89	0,18	47,67	282,99
2.	11,18	0,03	22,88	189,70	17,62	0,18	44,60	298,91
3.	8,67	0,02	36,69	126,20	14,99	0,31	42,01	218,36
(3.1) Mulj digestora								
1.	4,32	0,03	26,68	134,60	8,78	0,32	44,72	273,61
2.	12,36	0,03	21,66	277,00	16,76	0,95	36,66	375,77
3.	7,62	0,02	32,88	163,91	11,21	1,67	41,69	241,11
(4.1) Mulj homogenizatora								
1.	5,84	0,02	26,86	163,91	9,92	0,06	44,30	278,71
2.	9,16	0,02	26,99	163,10	16,15	0,34	53,32	287,53
3.	9,76	0,02	44,07	130,10	20,12	0,22	51,98	233,07
(5.1) Muljni kolač								
1.				86,68				243,18
2.				114,45				255,61
3.				95,00				243,97

Tabela 3.c.
SADRZAJ TESKIH METALA - LINIJA MULJA

Termin	Cd				Ni			
	A.	B.	C.	D.	A.	B.	C.	D.
1.1 Mulj primarnog taložnika								
1.	0,26	-	1,73	9,97	1,63	0,03	13,54	61,93
2.	0,47	-	1,45	9,67	4,24	0,02	13,36	86,99
3.	0,17	-	1,58	9,41	0,76	0,05	7,47	43,32
2.1 Mulj zgušnjivača								
1.	0,26	-	1,66	9,41	1,61	0,05	13,19	57,96
2.	0,51	-	1,53	8,17	3,71	0,07	12,95	62,93
3.	0,75	-	2,18	10,91	4,11	0,08	9,49	59,91
3.1 Mulj digestora								
1.	0,27	-	1,47	8,51	1,82	0,07	11,99	56,72
2.	0,57	-	1,12	12,68	5,03	0,24	8,19	112,73
3.	0,52	-	1,72	11,10	3,44	0,07	11,07	74,01
4.1 Mulj homogenizatora								
1.	0,33	-	2,00	9,29	2,27	0,01	13,08	63,75
2.	0,58	-	1,90	10,34	4,72	0,04	15,47	84,05
3.	0,69	-	1,86	8,08	-	0,04	15,03	-
5.1 Muljni kolač								
1.				7,15				91,49
2.				4,50				92,69
3.				4,98				98,66

Tabela 3.d.
SADRZAJ TESKIH METALA - LINIJA MULJA

Termin	Cr				Co			
	A.	B.	C.	D.	A.	B.	C.	D.
1.1 Mulj primarnog taložnika								
1.	2,59	0,05	12,79	98,71	0,25	0,02	1,43	9,67
2.	3,72	0,05	13,07	76,32	0,49	0,03	1,39	10,18
3.	1,09	0,02	0,72	61,97	0,15	0,02	0,72	8,64
2.1 Mulj zgušnjivača								
1.	2,47	-	13,04	88,85	0,21	0,01	1,55	8,45
2.	6,65	-	14,02	112,81	0,55	0,01	0,72	9,25
3.	1,33	1,90	0,29	19,43	0,55	-	1,22	8,00
3.1 Mulj digestora								
1.	2,47	0,02	16,51	76,97	0,33	0,01	1,63	10,13
2.	5,50	-	11,45	123,29	0,68	-	1,16	15,27
3.	3,56	-	11,30	76,59	0,42	0,01	1,47	9,04
4.1 Mulj homogenizatora								
1.	3,28	0,02	19,16	92,08	0,33	0,01	1,77	9,27
2.	4,82	-	16,26	85,83	0,67	-	2,04	11,93
3.	3,90	0,02	12,43	45,18	0,58	0,02	1,92	6,72
5.1 Muljni kolač								
1.				47,35				12,11
2.				56,52				12,41
3.				63,99				12,74

A- sadržaj metala u nativnom uzorku izraženja u mg/kg uzorka

B- sadržaj metala u supernatantu dobijenom centrifugiranjem i membran filtracijom, izražen u mg/l

C- sadržaj metala u talogu nakon centrifugiranja i membran filtracije izražen u mg/kg uzorka

D- sadržaj metala u uzorku izražen na kg suhe materije uzorka

Tabela 4.

SADRŽAJ TEŠKIH METALA: LINIJA VODE

Termin	Cd	Cu	Zn	Mn	Pb	Co	Ni	Cr
				µg/l				
Kolektor								
1.	-	5,0	195	90	10	-	-	-
2.	-	5,0	195	70	20	30	10	-
3.	-	-	-	-	-	-	-	-
Influent								
1.	14,93	22,10	9.320	1.598	830	149	194	478
2.	0,04	1584,0	11.628	2.180	2.035	145,3	290	581
3.	-	-	-	-	-	-	-	-
Poslije primarnog taložnika.								
1.	-	2,0	5,0	30	-	20	10	20
2.	-	7,0	200,0	100	5,0	20	10	50
3.	-	-	-	-	-	-	-	-
Efluent								
1.	-	5,0	120	70	-	10	10	70
2.	-	2,5	46	80	20	20	20	50
3.	-	-	-	-	-	-	-	-

LITERATURA

1. Velagić Habul Esma, B.Šaćiragić, Z.Hofman (1987): Preliminarna istraživanja sadržaja biljnih hraniva i teških metala u mulju postrojenja za prečišćavanje otpadne vode u Sarajevu. Naša vodoprivreda Sarajevo, No.11-12 (5-12)
2. Drače Z. (1984): Prikaz postrojenja za prečišćavanje otpadnih voda grada Sarajeva. Naša vodoprivreda Sarajevo. No. 7 (49-67)

PRIKAZ PROJEKTA POSTROJENJA ZA PREČIŠĆAVANJE OTPADNIH VODA GRADA ALEKSANDROVCA

Dr. Dejan Ljubisavljević, dipl.inž.gradj.
Snežana Daković, dipl.inž.tehn.*

R E Z I M E

Izloženi su problemi vezani za projektovanje uredjaja za prečišćavanje otpadnih voda naselja na manjim vodotocima. Dat je prikaz projekta postrojenja za prečišćavanje gradskih voda naselja Aleksandrovac Župski.

1. UVOD

Postrojenje za prečišćavanje otpadnih voda grada Aleksandrovca prečišćavaće gradske sanitarne otpadne vode i prethodno prečišćene industrijske otpadne vode u skladu sa predlogom Pravilnika o tehničkim i sanitarnim uslovima za upuštanje otpadnih voda u gradsku kanalizaciju.(u daljem tekstu Pravilnik).

Industrijske otpadne vode moraju se prethodno prečišćavati da bi se mogle upuštati u gradski kolektor. Naročito se mora zabraniti havarijska ispuštanja većih količina industrijskih otpadnih voda u gradski kolektor s obzirom na tip uredjaja za prečišćavanje - biološko prečišćavanje. Ovakva havarijska ispuštanja bi zaustavila biološke procese pa bi uredjaji morali da se prazne i ponovo formiraju i započinju sa radom. Ovo je potrebno regulisati odgovarajućom zakonskom regulativom i administrativnim merama.

2. SASTAV OTPADNE VODE KOJA DOLAZI NA UREDJAJ ZA PREČIŠĆAVANJE

Projektom je predvidjeno zajedničko prečišćavanje industrijskih i sanitarnih otpadnih voda Aleksandrovca, pod uslovom da se sve industrijske otpadne vode predtretmanom dovedu do kvaliteta predvidjenog predloženim Pravilnikom.

Raspoloživi podaci o kvalitetu otpadnih voda su relativno oskudni, ali omogućavaju da se sa zadovoljavajućim stepenom pouzdanosti utvrdi kvalitativan sastav otpadnih voda.

* Gradjevinski fakultet, Beograd

zaštite voda / Bar, 1990.

ODNOS EDTA-e EGTRAKTIBILNIH I UKUPNIH KONCENTRACIJA TEŠKIH METALA U MULJU GRADSKIH ODPADNIH VODA IZLOŽENOM DJELOVANJU ATMOSFERILIJA

Dr Esma Velagić Habul, Sanja Sarić
Poljoprivredni fakultet, Sarajevo

Zlatko Hofman
Zavod za vodoprivredu BiG, Sarajevo

Muljni "kolač" dobijen na postrojenju za preradu gradskih otpadnih voda u Sarajevu, je odložen na zemljište u decembru 1986.,aprilu 1987 i julu 1987.god. i tako izložen djelovanju atmosferilija. Godinu dana kasnije (u izabra vremenskim intervalima od decembra 1987. do marta 1989.)u 8 navrata uzeti su uzorci i analizirani na ukupan i EDTA-ekstraktibilan sadržaj Fe,Zn,Mn,Cu,Ni,Cd,Co i Cr,s ciljem da se utvrdi količina i promjena u distribuciji metala izmedju ove dvije frakcije u funkciji vremena (raspada organske materije).Rezultati su obradjeni statički (Studentov test,korelacija i trendovi) i pokazuju da korelacija izmedju ove dvije frakcije postoji gotovo isključivo za metale u uzorcima svežeg muljnog kolača.Dinamika distribucije metala u odloženim muljevima iskazuje i efekte depozicije metala iz atmosfere, što doprinosi nepostojanju statistički opravdanih korelacija.

N -34

Jedan od osnovnih negativnih efekata odlaganja mulja gradskih otpa-ih voda na poljoprivredno zemljište je akumulacija teških metala,što se da putem lanca ishrane preko biljaka prenosi do čovjeka. Kako u mulju, ko i u zemljištu teški metali stvaraju stabilne komplekse sa organskom terijom. Veća apsorpcija od strane biljaka se javlja nakon pomanjkanja postavljanja dinamičke ravnoteže koncentracijom,što se obično iskazuje totoksičnim efektom 10-150 godina uzastopnog odlaganja mulja na poljo-ivredno zemljište.

Cilj rada je bio da se u odredjenom vremenskom periodu (decear 1986-mart 1989.) utvrde količine teških metala u svježem muljm "kolaču) i muljevima koji su pored postrojenja odloženi na zejište i izloženi djelovanju atmosferilija. Isti uzorci podvrgnuti ekstrakciji sa EDTA-om. Smatra se da ova metalna frakcija nastavezivanjem lakše pristupačnih,dosputnih formi metala u širem opgu pH,i da za većinu metala predstavlja fiziološki dostupnu kolinu biljkama.

METOD RADA

Svež muljni kolač,postrojenja za preradu otpadnih voda grada Sarajeva analiziran je na ukupan i EDTA-ekstraktibilan sadržaj Fe, Mn,Zn,Cu,Ni,Cd,Co i Cr. Uzorci su uzeti: u decembru 1986 g., 15.2.1988,16.3.1988,20.4.1988.,24.2.1989.,i 13.3.1989.Mulj uzet u decembru 1986.godine, zatim u aprilu 1987 i julu 1987.odložen je na površinu pored postrojenja. Uzorci ovih,odloženih muljeva su uzeti godinu dana nakon odlaganja tj, u decembru 1987.,25.1.1988.,15.2. 1988.,16.3.1988., 1.4.1988.,16.5.1988.,10.11.1988 i 13.3.1989.god.

Uzorci su u laboratoriji osušeni (vazdušno suhi) i homogenizirani. Za odredjivanje ukupnog sadržaja metala uzorci su spaljeni kombinacijom konc.HNO_3+$HClO_4$ a za EDTA-ekstraktibilnu frakciju mućkani na rotacionoj mućkalici 30 min. sa 1% rastvorom Na_2EDTA u odnosu 1:10. Svi metali su odredjeni metodom AAS,na instrumentu Puy Unicam.

REZULTATI I DISKUCIJA

U tabeli 1. prikazani su rezultati hemijskih analiza a u tabelama 2. i 3. rezultati njihove statičke obrade.

Očekivalo se da će u definisanom vremenskom periodu doći do razgradnje organske materije, što će biti praćeno smanjenjem ukupne količine metala (oslobadjanje iz organskog kompleksa i ispiranje) ili povećanje ekstraktibilnih,lakše pokretnih,dostupnih količina. Medjutim, očito je da u interakciji sa atmosferilijama ovim procesima doprinosi i efekt taloženjem metala iz atmosfere koji tu egzistiraju uslijed aerozagadjenja,što je karakteristično za Sarajevo. Drugim riječima,dinamika koncentracije praćenih metala u izabranom vremenskom intervalu je rezultat ne samo osobina mulja, stabilnosti odgovarajućih kompleksa,destrukcije organske materije nego i depozicije metala u uslovima aerozagadjenja.
Uočljivo je da je zavisno o vrsti metala,u praćenom vremenskom intervalu došlo do nakupljanja ukupne količine (Fe,Mn,Zn,Cu), njenog smanjenja (Ni,Cr) odnosno ukupna količina metala varira (Co,Cd). Medjutim ne treba gubiti iz vida činjenicu da se radi o dosta heterogenoj skupini rezultata što se kod pojedinih analiza manifestovalo visokim vrijednostima za standardnu devijaciju i koeficijent varijacije (tabela 3.).

Od ukupne količine Fe u svježem mulju,6" je EDTA-ekstraktibilno. U odloženim muljevima, ukupna količina se povećava ali za esktraktibilna smanjuje i to na gotovo 1/3: za mulj iz dec.86 2,6%,april 87.-2,48% i juli 87.-3,2%. Za svježi mulj koeficijent korelacije izmedju dvije praćene frakcije je veoma visok (0,92) dok za odložene muljeve korelacija gotovo ne postoji.

U svježem muljnom kolaču postoji veoma visoka korelacija izmedju ukupne i EDTA-ekstraktibilne količine Mn. Kod odloženih muljeva ona ne postoji. U svežem mulju ekstraktibilna količina čini oko 38% ukupne količine dok je kod odloženih muljeva 43,4% (dec.86.)45,8 (april 87) i 34,o% (juli 87).

U odnosu na svjež mulj, učešće ekstraktibilne količine Zn u ukupnoj (43,9%) i odloženim muljevima se mijenja više zavisno o dobi kad je mulj odložen nego o dužini odležavanja: dec.86.-48%,april 87.-49% i juli 87.58,7%.

U odnosu na svjež mulj, količina ekstraktibilne frakcije Cu u odležanim muljevima je gotovo dvostruko veća: mulj 24,8%,dec.86-45,2%,april 87.-19,4% i juli 87.-24,7%.Cd je element kod koga je najveće učešće ekstraktibilne frakcije u odnosu na ukupnu količinu elementa, nakon odležavanja mulja. U svježem muljnom kolaču one iznose 39,6%,a u muljevima iz decembra 86.-55,9%,aprila 87.-82,3% jula 87.-66,5%.

Co ima malo učešće u ekstraktibilnoj frakciji:18% u svježem mulju, 13,2% u mulju iz dec.86.,11,6% iz aprila 87.,i 15,7% iz jula 87. Kod Cr je veoma mala količina vezana u kompleks sa EDTA-om jer se ovaj kompleks sporije i teže gradi. Za komparaciju kod ovog elementa smo vršili i ekstrakciju sa HNO_3.2mol/dm^3. Ova ekstrakcija pokazuje da se Cr nalazi u visokom procentu kao forma dostupna za biljke: u svježem muljnom kolaču 80%,u mulju iz dec.86.-72%, u mulju iz aprila 87.-58% i u onom iz jula 80%.

TABELA 1: REZ. ...TI HEMIJSKIH ANALIZA

TERMIN	Fe(mg/g)		Zn(mg/g)		Mn(µg/g)		Cu(µg/g)		Ni(µg/g)		Cd(µg/g)		Co(µg/g)		Cr (µg/g)		
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	III
SVJEŽ MULJNI "KOLAČ"																	
12.87	22,4	0,80	2,17	1,20	454,6	213,4	327,5	111,1	46,7	10,9	9,1	3,6	9,3	1,9	82,2	0,8	67,7
15.2.88	23,06	0,33	2,73	1,14	639,0	224,4	348,8	199,1	51,0	6,8	5,5	2,5	9,3	1,0	68,3	0,8	47,0
16.3.88	20,72	1,11	2,09	1,18	420,5	160,6	294,3	94,6	46,3	13,3	8,9	5,7	9,5	2,4	90,5	1,1	64,5
20.4.88	23,13	1,07	2,29	1,36	506,3	224,4	308,4	73,7	63,1	10,9	14,0	7,8	10,3	2,0	93,5	0,9	64,5
24.2.89	15,93	2,4	2,52	0,74	264	89,1	337,9	6,3	144,8	90,2	10,6	1,9	10,2	1,7	177,0	-	150,4
13.3.89	15,51	1,6	2,58	0,68	257,3	70,4	354,4	5,9	141,7	74,8	10,3	1,7	9,5	1,5	148,9	-	138,5
MULJ ODLOŽEN U DECEMBRU 1986																	
12.87	27,48	0,61	3,16	1,30	739,0	240,0	347,2	177,1	62,4	9,2	6,0	2,5	11,3	1,3	80,0	0,9	49,0
25.1.88	28,21	0,57	2,60	1,35	574,7	290,4	375,2	198,0	41,9	10,0	4,5	2,7	8,1	1,3	57,5	1,1	44,0
15.2.88	23,10	0,49	2,69	1,33	600,3	222,0	333,1	165,0	49,8	7,3	4,9	2,3	9,2	1,1	58,2	0,8	49,0
16.3.88	24,79	0,97	5,19	1,50	658,2	319,0	334,5	182,0	47,9	10,5	5,3	2,1	8,9	1,1	67,8	0,8	45,5
21.4.88	22,17	0,68	2,56	1,55	651,6	288,2	306,2	20,9	45,4	9,6	5,3	5,7	8,9	1,4	66,9	0,8	45,5
16.5.88	21,57	0,70	2,62	1,53	643,1	327,8	330,4	194,7	46,4	10,3	5,2	2,7	9,5	1,4	72,6	0,8	47,0
10.11.88	25,28	0,70	2,26	1,32	687,8	382,8	370,7	202,4	48,8	9,0	4,9	2,7	10,2	1,8	66,5	0,8	47,0
13.3.89	19,06	0,32	2,25	1,33	613,0	173,8	286,2	124,3	54,1	6,6	5,7	2,7	11,1	0,9	70,7	-	45,5
MULJ ODLOŽEN U APRILU 1987																	
12.87	20,24	0,65	2,67	1,37	626,4	272,8	366,0	196,0	48,0	10,3	5,1	2,5	8,1	1,3	65,2	0,8	45,4
25.1.88	40,23	0,66	5,07	1,66	777,7	222,2	562,9	237,6	78,1	10,3	_	14,3	15,0	1,5	214,8	1,7	55,0
15.2.88	22,79	0,59	2,77	1,41	64,6	292,6	355,6	178,2	55,8	13,3	5,4	2,4	9,3	1,0	66,1	0,7	47,0
16.3.88	-	-	-	-	-	193,6	-	-	-	-	-	-	-	-	-	-	-
21.4.88	42,64	0,57	2,72	1,31	647,5	275,0	330,0	196,9	37,7	8,6	5,7	2,5	9,1	1,0	71,7	0,8	45,5
16.5.88	25,00	0,84	3,42	1,97	474,3	345,4	358,2	224,4	57,3	11,5	13,8	8,4	0,6	1,4	59,6	0,8	49,5
10.11.88	21,30	0,91	2,98	1,88	529,3	202,4	386,2	327,8	49,3	11,3	13,0	8,5	0,3	1,5	86,8	0,9	79,0
13.3.89	18,92	0,43	2,62	1,35	565,4	149,6	318,7	114,4	56,5	9,0	6,5	2,2	2,4	1,0	73,6	-	53,5
MULJ ODLOŽEN U JULU 1987																	
12.87	23,39	1,06	3,07	1,75	518,1	167,2	424,3	155,1	50,2	13,0	12,6	6,6	9,3	1,7	84,9	0,8	69,4
25.1.88	22,93	0,22	3,04	1,93	492,1	162,8	454,8	275,0	50,7	12,4	12,4	9,4	10,3	1,4	105,3	0,5	83,9
15.2.88	22,15	0,46	3,05	1,62	434,2	96,8	371,5	264,0	50,4	12,6	13,1	8,0	9,4	1,1	83,9	0,8	66,1
16.3.88	22,26	1,10	3,00	1,63	448,3	193,6	383,6	92,4	50,4	16,1	13,0	5,7	9,5	2,3	90,3	0,8	70,1
21.4.88	21,60	1,08	3,30	2,10	499,4	239,8	411,4	231,0	52,0	15,4	13,4	8,4	9,8	1,9	96,0	1,1	79,0
16.5.88	26,07	0,59	3,50	1,80	516,9	135,3	366,0	208,0	51,5	9,8	3,4	7,9	10,1	1,4	90,9	1,1	67,7
10.11.88	24,50	0,92	3,17	2,00	457,4	171,6	370,3	298,1	49,5	12,4	14,8	10,0	10,4	1,7	87,7	0,5	72,6
13.3.89	21,05	0,53	3,11	2,00	440,0	128,7	376,3	181,5	50,8	11,2	14,7	8,8	13,2	1,4	90,8	-	75,8

I - ukupan sadržaj
II - sadržaj dobijen ekstrakcijom sa EDTA-om
III - sadržaj dobijen ekstrakcijom sa HNO_3, 2 mol/dm^3.

THE JICA STUDY TEAM OFFICE
FOR THE REHABILITATION OF
THE SEWERAGE SYSTEM
OF CANTON SARAJEVO
VODOVOD I KANALIZACIJA
Tel.:++387-71-458-630
Fax:++387-71-458-630
Mobile:++387-90-160-190
Date : 28.06.99

To Mr.Midhat BISCEVIC
Director,
Canton Public Communal Company,
"Vodovod i Kanalizacija",
Tel : ++387-71-668-260
Fax : ++387-71-204-574

Re: Report for Meeting with "RAD" (Canton Public Municipal Enterprise) regarding the Wastewater Sludge Disposal of Sarajevo WWTP Project.

Dear Sir,

The Study Team had commenced the second site survey for the Feasibility Study of the Sarajevo WWTP. As per our discussion during the meeting held on 26 to 28 May 1999, the activities of our team stationed in ViK office at Terezija and WWTP site at Butila, are now in full swing.

The study team and ViK had a meeting with RAD on 24 June 1999 at their office in Paromilinska regarding the above matter which will be occur during operation of Sarajevo WWTP. We have confirmed several important issues as per our Note.

The Study Team would like to suggest to Vik as well as Vodoprivreda to keep in touch with them for further discussion about this issue.

2. Consent of the Canton Sarajevo to accept digested dewatered sludge cake for final disposal at landfill site. Estimated dewatered sludge cake quantity and mass are as follows:

The year 2015	Quantity:	144 m3/day
	Mass	: 160,000 kg/day
The year 2000	Quantity:	88 m3/day
	Mass	: 98,000 kg/day

contd...../2

Sincerely yours,

Kaoru SUZUKI
Team Leader,
JICA Study Team

encl.: As above.

c.c. 1. Mr.Fahrudin PILAVZIC
General Manager,
Canton Public Communal Company,
Vodovod i Kanalizacija
8 J. Cernija St.
Sarajevo 71000
Bosnia i Herzegovina
Tel : ++387-71-447-741
Fax :++387-71-440658

2. Prof. Dr. Mehmed SARIC
Assistant Minister,
Ministry of Agriculture, Water Management and
Forestry of Federation of Bosnia Herzegovina (MOAWMF),
St. Hamdije Kresevljakovic 3,
Sarajevo 71000
Tel : ++387-71-443-338
Fax :++387-71-663-659

3. Mr.Selim BABIC
Director of Public Hygiena,
Cantonal Public Municipal Enterprise,
"RAD",
Paromilnska 57, 71000 Sarajevo,
Bosnia i Herzegovina
Tel : ++387-71-616-101
Fax : ++387-71-656-812