Assessment of water quality in the Mandl/ Leie-Catchments-BELGIUM

Identification of water quality using macro invertebrates and physiochemical analysis by Belgian Biotic Index (BBI)

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I. INTRODUCTION

Purpose of project:

To identify the water quality of water bodies using macroinvertebrates and physicochemical analysis using The Belgian Biotic Index (BBI)

II. Materials and methods:

Sampling Methods and Materials

This project includes sampling, sorting, identification of organisms, analysis of the project results in general.
Various samples from different sites were taken for the investigation of the biological, physical and chemical parameters. Sampling methods used include hand net sampling, artificial substrates and grab sampling for different parameters. The procedures, reagents and materials used during sampling, onsite investigation and during laboratory analysis are indicated under each respective sampling methods and tasks as follows.

1. Sampling

i). Hand Net sampling from location one

a) Materials used:

- ✓ Wadding suit
- ✓ Hand net
- ✓ Bucket
- ✓ Tape
- ✓ Markers

b). Sampling procedure

- ✓ After everything was ready for the sampling, the sample was collected for five minutes
- ✓ The sampling was carried out from the downstream from treatment plant
- ✓ The bottom of the stream was kicked with feet while walking against the current.
- ✓ The hand net was kept open to the sampler and moved up and down while sampling.
- ✓ The sample was rinsed from time to time in order to remove the sludge.
- ✓ Then the sample was transferred to the bucket.
- ✓ The hand net was cleaned and replaced
- ✓ The bucket was labeled carefully
- ✓ The sample brought to the lab and the macro-invertebrates collected into a vial containing alcohol from a tray. The organisms were also counted. Identification through stereoscopic microscope was done. Assigning the biotic index is as below.

- ✓ **The Belgian Biotic index scoring**

- ✓ **Step 1**: The organisms identified and counted in the sample were labeled with letters as in the following table:

A	1 individual	D	51-100 individuals
B	2-10 individuals	E	101-1000 individuals
C	11-50 individuals	F	1001-1000 individuals
		G	>1000 individuals

Step 2: the corresponding score in the second column of taxonomic list, except the taxa represented by one individual was circled
Step 3: the number represented by at least 2 individuals in first column of taxonomic list was counted.
Step 4: the lowest circled score looked for in the second column was counted and frequency noted (Class frequency)
Step 5: The number of taxa (=systemic units) (step 3) gives the table to calculate the biotic index.
The lowest circled score (step 4) gives the biotic index.
The crossing of this raw and column determined the Belgian Biotic index.
(See the attached **field protocol in annex-I**)

ii). Sampling location 2/ Artificial substrate sampling
Materials used

- ✓ Three buckets with lid
- ✓ Tape
- ✓ Markers

b). Procedures

- ✓ The artificial substrate (AS) kept in the water for three consecutive weeks were pulled out turn by turn out of the water and transferred in to the buckets
- ✓ The buckets were filled with water until the AS was fully covered.
- ✓ Finally, the buckets were labeled carefully as X, Y, and Z, by noting the site of each AS (See annex 2 for field protocol).

- ✓ The artificial samples collected in this manner were brought to the lab.

- ✓ All artificial substrates were washed on a 0.5mm sieve and transferred carefully in to a jar.

- ✓ The collected macro-invertebrates with some debris spread on a tray and based on each species type collected on vial in alcohol. This was analyzed with stereoscopic microscope. The phylum, class, order and family were analyzed.

The assignment on the Belgian Biotic index was done as in the Net sampling procedure.
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iii). Sampling location 3

This sampling station is located after the discharge effluent constructed on the wetland of Wontergen

1**. pH determination and water temperature measurement**

a) Materials used

- ❖ PH electrode
- ❖ Water sampling jar

b). Procedure

- ❖ The water to be analyzed was sampled by using the jar
- ❖ The electrode was inserted in to the water and the readings of the pH and the temperature were taken and recorded on the spot.

2). Orthophosphate determination

- ❖ Orthophosphate measurement in terms of PO_4 was done using the chemical field kit according to the procedure indicated on the kit
- ❖ The sample was allowed to react with the coloring reagent and the color was compared with the standard comparison colour on the kit.
- ❖ The result was finally recorded
- ❖ The waste water was transferred to indicated field reservoir

(See attached annex-III for field protocol)

iv). Sampling location 4 (Nitrate-nitrite and ammonia determination)

- Here the sampling and investigations were done for the Nitrate-nitrite and ammonia
- Both Nitrate- nitrite and ammonia were determined onsite in terms of Nitrate and NH_4 respectively
- For both determinations, the chemical field kits were used
- After adding colour producing reagent for the three nitrate, nitrite and nitrate the product compared with colour indicator on the kit.
- Finally, the results were recorded

(See attached annex-IV for field protocol)

v). **Sampling location 5 (Mandelbeek)**

1). Dissolved Oxygen (DO) determination

a) Materials used

- DO electrode

Procedure

- First the water sample was taken by using the sampling bottle which was filled to the neck
- Calibrating the DO electrode by means of calibration tube and inserted in to the sample.
- The DO concentration was measured by moving the electrode back and forth and perpendicular to the water surface
- O_2 concentration (mg/L), saturation percentage (%) and water temperature were recorded

b) **Method**: the method used for this analysis was Winkler method

With a DO bottle the sample was filled and a base reagent was added. By adding the appropriate colour producing reagents the concentration was measured by the kit.

2). Water Hardness measurement

Hardness was analyzed using field kits by comparing the colour on the kit.

3). Light penetration in the water

- The light penetration depth of the stream was measured by sechi disk. The disk was allowed to go until it disappears, and then the depth of the disappearance measured.

III. RESULTS

Sampling of water for Belgian Biotic index analysis

Sampling date 06 May 2004

Table 1: parameters analyzed in the field except the BOD values.

	Sampling site 1	**Sampling site 2**	**Sampling site 3**	**Sampling site 4**	**Sampling site 5**	**Remark**
Conductivity (µs/cm)	1171	1181	832	764	1014	
Temperature (^{0}C)	16.1	17.4	14.9	17.5	17.2	
pH	7.8	7.73	7.67	7.7	7.5	
Phosphate PO_4^{3-} (mg/lit)	5	2.75	2.7	1.5	>3.75	
Nitrate NO_3^- (mg/lit)	25	10-25	<10	35	25	
Nitrite NO_2^- (mg/lit)	0.5	0.5	0.3	0.75	0.5	
Ammonium (NH_4) (mg/lit)	5.0	6.5	8.0	0.5	10	
Dissolved oxygen (mg/lit)	9.3	6	10	9.7	6.6	
Dissolved oxygen %	97	64	100	93	70,	
Winkler Dissolved oxygen (DO), mg/lit	7.8	5.4	7.7	8.9	5	
BOD (mg BOD/l)	**44.4**	**35.4**	**17.6**	**17**	**24.2**	
Hardness (^{0}d)	16	17	19	>21 ^{0}H	14.(medium hard)	
Sechi disk transparency (cms)	20	20	Till the bottom	30	20 to the bottom	

Table 2: provided from the from environmental toxicology and aquatic ecology

	1	2	3	4	5
NO_3^- (mg N/l)	1.3	2.5	4.0	5.3	2.0
PO_4^{3-} (mg P/l)	1.7	1.6	1.3	0.5	1.3
NH_4^+ (mg N/l)	**5.5**	**5.0**	**7.5**	**0.4**	**12.0**
COD (mg COD/l)	**222**	**177**	**88**	**85**	**121**
BOD (mg BOD/l)	**44.4**	**35.4**	**17.6**	**17**	**24.2**

Table 3: results from macro invertebrates for artificial sample location 2

Sampling site (sampling date 06 May 2004)	**Phylum**	**Class**	**order**	**Family**	**Number organisms**	**number**	**Taxa**
Location 2 Artificial sample ASX	Arthropoda	Crustacea	Isopoda	Asselidae	100	D	5
	Arthropoda	Insecta nymphs	Odonata (suborder Zygotera)	Coenagriidae	4	B	4
	Arthropoda	Insecta (pupae)	Diptera larvae	Chirinomidae	14	C	6
	Arthropoda	*Insecta*		*Chironomidae*	*150*	*E*	*6*
	Annelide	*oligochaeta*		*Tubificdae*	*21*	*C*	*6*
	Annelidae	*Hirudinea*		*glossiponidae*	4	*B*	*5*
Location 2 Type of sample: Artificial sample ASY	Arthropoda	Crustacea	Isopoda	Asselidae e	14	C	5
	Arthropoda	*Insecta(larva)*		*Chironomidae*	50	C	6
	Mollusca	gastropoda		Only the shell	2	B	
	Arthropoda	*Insecta*	Odonata	Coenagriidae	1	A	4
	Annelide	*oligochaeta*		*Tubificdae*	32	C	6
	Arthropoda	*Insecta (pupa)*		*Chironomidae*	5	B	6
	Annelidae	*Hirudinea*		*glossiponidae*	1	A	5
Location 2 Type of sample: Artificial sample ASZ	*Arthropoda*	*Insecta (pupae)*		*Chironomidae*	1	A	6
	Arthropoda	Crustacea	Isopoda	Asselidae	12	C	5
	Arthropoda	Insecta nymphs	Odonata	Caenagriidae	2	B	4
	Arthropoda	*Insecta (larvae)*	*diptera*	*Chironomidae*	110	E	6
	Arthropoda	*Insecta (larvae)*	*diptera*	*Chironomidae (non-thummiplumsus*	2	B	---

Table 4 results from macro invertebrates for sampling location l using Hand nets

Sampling site 1	**Phylum**	**Class**	**order**	**Family**	**Number organisms**	**Type of sample**	**number**	**Taxa**
Hand net	*Arthropoda*	*Insecta*		*Chironomidae*	110		E	6
	Mollusca	gastropoda		Hydrobidae	29	Shells only	C	
	Arthropoda	*Insecta*	Odonata	Caenagriidae	1		A	4
	annelidae	Hiruinae		Glossiphonidae	71		D	5
	Annelide	*oligochaeta*		*Tubificdae*	13		C	6
	Arthropoda	Crustacea	Isopoda	Asselidae	250		E	5

Table 5: Belgian Biotic index results

	Group A	Group B	Group C	Group D	Group E
Sample code	Location 1	Location 2	Location 3	Location 4	Location 5
Artificial sample X	4	5	3	4	3
Artificial sample Y	4	3	3	3	3
Artificial sample Z	4	4	3	3	3
Total BBI for artificial sample	4	4	3	4	4
Hand net	2	3	2	3	3

IV. DISCUSSION

Table 6: BBI CALCULATION for location 1 and location 2

sample code	number taxa	Belgian biotic index (BBI)	Location
Artificial substrate X	5	4	2
Artificial substrate y	4	3	2
Artificial substrate z	3	4	2
Hand net	4	3	1

Table 7: the total sum of macroinvertebrates of the sample collected from artificial substrate at location 2. Sample code ASX, ASY, ASZ.

Family of organisms	Total number organisms at the location 2 by hand net	Number	Tolerant Index (score)	The Belgian biotic index for the location 2	Class	Colour code	significance
Asselidae	126	E	5	4	IV	Orange	Slechte biologische kualiteit
Caenagriidae	8	B	4				
Chironomidae	332	E	6				
Tubificdae	53	D	6				
Glossiphonidae	5	B	5				

From table the total biotic index after comparing with the Belgian biotic index table it is 4.

- The number of taxa with more than 1 individual is 5
- The lowest circled score in this case is B-4
- Frequency of occurrence = one

- Then the total biotic index is 4

Table 8: The Dutch Method

Location	% O_2 saturation	Score	BOD_5^{20} mg/lit	Score	NH_4^+-N (mg/l)	Score	Average score	Remark
1	97	1	44.4	5	5.5	5	11	
2	64	3	35.4	5	5.0	4	12	
3	100	1	17.6	5	7.5	5	11	
4	93	1	17	5	0.4	1	7	
5	70	3	24.2	5	12.0	5	13	

Table 9: water quality assessment according to Dutch Method

location	Average score	class	Colour code
1	11	4	orange
2	12	4	orange
3	11	4	orange
4	7	2	grey
5	13	4	orange

Table 10: The LISEC Method

Location	% O_2 saturation	Score	BOD_5^{20} mg/lit	Score	NH_4^+-N (mg/l)	Score	PO_4^{3-}P (mg/lit)	Score	Average score	Remark
1	97	1	44.4	5	5.5	5	1.7	5	16	
2	64	3	35.4	5	5.0	4	1.6	5	17	
3	100	1	17.6	5	7.5	5	1.3	4	15	
4	93	1	17	5	0.4	1	0.5	3	10	

5	70	3	24.2	5	12.0	5	1.3	4	17	

Table 11: water quality assessment according to LISEC Method

location	Average score	class	Colour code	quality
1	16	4	orange	Bad, polluted
2	17	4	orange	Bad, polluted
3	15	4	orange	Bad, polluted
4	10	3	yellow	Moderate, doubtful
5	17	4	orange	Bad, polluted

Table 12 Location 1 comparing the results with VlAREM II water quality standard

parameter	Results analyzed	VLAREM II	Acceptance
Conductivity (µs/cm)	1171	<1000	Not good
Temperature (^{0}C)	16.1	<=25+3	Good
pH	7.8	6.5-8.5	Good
Phosphate PO_4^{3-}-p (mg/lit)	1.7	<0.30	Not good
Nitrate NO_3^- -N(mg/lit)	1.3+0.15	<10	Good
Nitrite NO_2^-- N(mg/lit)			
Ammonium (NH_4-N) (mg/lit)	5.5	<0.02	Not good
Dissolved oxygen (mg/lit)	9.3	>5	Good
Hardness (^{0}d)	16	----	
Sechi disk transparency (cms)	20	------	
Artificial sample	4	>6	Not good
Hand net	2	>6	Not good

Table 13 Location 2 comparing the results with VlAREM II water quality standard

parameter	Results analyzed	VLAREM II	Acceptance
Conductivity (µs/cm)	1181	<1000	Not good
Temperature (^{0}C)	17.4	<=25+3	Good
pH	7.73	6.5-8.5	Good
Phosphate PO_4^{3-}-p (mg/lit)	1.6	<0.30	Not good
Nitrate NO_3^- -N(mg/lit)	2.5+0.15	<10	Good
Nitrite NO_2^-- N(mg/lit)			
Ammonium (NH_4-N) (mg/lit)	5.0	<0.02	Not good
Dissolved oxygen (mg/lit)	6.0	>5	Good
Hardness (^{0}d)	17^{0}H	----	
Sechi disk transparency (cms)	20	------	
Artificial sample	3	>6	Not good
Hand net	2	>6	Not good

Table 14 Location 3 comparing the results with VlAREM II water quality standard

parameter	Results analyzed	VLAREM II	Acceptance
Conductivity (µs/cm)	832	<1000	good
Temperature (^{0}C)	14.9	<=25+3	Good
pH	7.67	6.5-8.5	Good
Phosphate PO_4^{3-}-p (mg/lit)	1.3	<0.30	Not good
Nitrate NO_3^- -N(mg/lit)	4+0.09	<10	Good
Nitrite NO_2^-- N(mg/lit)			
Ammonium (NH_4-N) (mg/lit)	7.5	<0.02	Not good
Dissolved oxygen (mg/lit)	10	>5	Good
Hardness (^{0}d)	2.8	----	
Sechi disk transparency (cms)	Till the bottom	------	
Artificial sample	3	>6	Not good
Hand net	2	>6	Not good

Table 15 Location 4 comparing the results with VlAREM II water quality standard

parameter	Results analyzed	VLAREM II	Acceptance
Conductivity (µs/cm)	764	<1000	good
Temperature (^{0}C)	17.5	<=25+3	Good
pH	7.7	6.5-8.5	Good
Phosphate PO_4^{3-}-p (mg/lit)	0.5	<0.30	Not good
Nitrate NO_3^- -N(mg/lit)	5.3+0.23	<10	Good
Nitrite NO_2^-- N(mg/lit)			
Ammonium (NH_4-N) (mg/lit)	0.4	<0.02	Not good
Dissolved oxygen (mg/lit)	9.7	>5	Good
Hardness (^{0}d)	21^{0}H	----	
Sechi disk transparency (cms)	3	------	Not good
Artificial sample	4	>6	Not good
Hand net	3	>6	Not good

Table 16 Location 5comparing the results with VlAREM II water quality standard

parameter	Results analyzed	VLAREM II	Acceptance
Conductivity (µs/cm)	1014	<1000	Not good
Temperature (^{0}C)	17.5	<=25+3	Good
pH	7.5	6.5-8.5	Good
Phosphate PO_4^{3-}-p (mg/lit)	1.3	<0.30	Not good
Nitrate NO_3^- -N(mg/lit)	2+0.15	<10	Good
Nitrite NO_2^-- N(mg/lit)			
Ammonium (NH_4-N) (mg/lit)	12	<0.02	Not good
Dissolved oxygen (mg/lit)	6.6	>5	Good
Hardness (^{0}d)	14	----	
Sechi disk transparency (cms)	20	------	
Artificial sample	4	>6	Not good
Hand net	3	>6	Not good

Table 17 Water quality status obtained by using Prati Index.

	BOD (mg/l)	Prati	COD (mg/l)	Prati	NH4-N	Prati	DO	Prati	NO3-N	Prati	pH	Prati	average	sampling location
	X	score	X	score	X	score	X	score	X	score	X	score	score	status
location 1	29.6	5	22.2	5	14.13345	5	0.24	1	1.261702	2	0.64	1	3.166667	polluted
location 2	23.6	5	17.7	5	13.30704	5	2.88	3	1.907608	2	0.5329	1	3.5	polluted
location 3	11.73333	5	8.8	5	17.19491	5	0	1	2.567593	3	0.4489	1	3.333333	polluted
location 4	11.33333	5	8.5	5	2.6956	3	0.56	1	3.067514	3	0.49	1	3	polluted
location 5	16.13333	5	12.1	5	23.14392	5	2.4	3	1.656633	2	0.25	1	3.5	polluted

Table 18 Summary of the index results

Method	Location 1	Location 2	Location 3	Location 4	Location 5
De Prati index	polluted	polluted	polluted	polluted	polluted
The Dutch	orange	orange	orange	Grey	orange
Lisec	Bad, polluted	Bad, polluted	Polluted, polluted	Moderate, doubtful	Bad, polluted
BBI (artificial substrate)	bad	bad	bad	bad	bad
BBI (Hand net)	worst	bad	worst	bad	bad

The Dutch Method, The LISEC Method, and Prati method which are used to evaluate the Physico-chemical water quality have shown results which are in agreement to each other and the biotic index, i.e. BBI.

According to the VLAREM water quality standard compared above the water quality of the sources are poor and do not meet the standard.

The most important cause of pollution for the water sources is

- Fertilizers from the farmlands
- Organic wastes from cow dung.
- Industrial water effluent from the nearby textile industry
- Municipal waste water discharge from treatment plant.

Discussion on the location 2 artificial substrate sample

The most sensitive species found in our artificial sample are the ones with less number. This is Odonata Coenagriidae because quantitatively very few in all the samples compared to other groups found. It is also observed that species Chrinomidae and Asselidae have dominated the sample. Their number is very high compared to the others.
The types of species found are limited. Hence the diversity of species is small. This is the character or indicator of polluted water

However, from the taxa Identified some are small in number while the others are large in number quantitatively compared to each other.

The artificial sample was collected from location 1 upstream by the waste treatment plant. Sample code ASZ is closer to the treatment side while ASX is in the opposite side of the treatment plant. ASY is in the middle of ASX and ASY across the river. In most cases it is observed that sample ASX has large number of organisms than ASY and ASZ. However ASY has the least number of organisms. This may indicate that the organisms prefer the location where the stream velocity is less.

Comparison of the hand and artificial substrate on each location

Referring Table 5: Belgian Biotic index results of all the sampling locations indicates that the biotic index for hand net is less than the artificial substrate sample. Hence this is an indicator that the artificial substrate method is much effective compared to the Hand net. Maybe because all the samplers are not skilled and their first time that they were not able to collect all of the organisms.

V. CONCLUSION

1. The water quality analysis based on biotic index (BBI) is more informative in predicting water quality. However both the physicochemical and the BBI have to be supported by each other for good results
2. From the above it was concluded that the water was not good in quality in all locations.

Appendix:

Field Protocol- Biological assessment of surface water

- Location: spel Brook
- Water course
- Station No: One
- Municipality: Tielt
- Description
- Hours: 2:07 P.M.
- weather conditions: Cloudy, before and during sampling

- Microhabitat

Type: canal
Width (m): (1 - 5)
Depth (av. m) (0.1 – 0.5)
Slope (0/00): (< 1)
Current speed: Slow
Substrate type: brook bed
: Dominant- silt, muddy (< 0.2 mm)
Substrate condition: covered with organic materials, leaves and dark in color
Transparency (Sechi cm): very turbid (< 5)
Temperature:
Hardness:
Oxygen:
PH:
Exposure: Open
Structure of the bank: concrete

BIOCENOSES (MICRO-HABITATS)
Sampling technique: Hand net
Sampled area: (2m x 6m)
Sampling time: 7minutes
Aquatic vegetation… (1) Scarce
Middle Bank
Macroalgae……..
Phrophytes…….
Sewage fungi
Macro-invertebrates:
Surrounding environment: Agriculture and pastures

Water colour; Dark brown Macro-optical pollution:

Remarks: some small white slimy