Industrial Zone of Koprivnice - Vlcovice
Koprivnice Business Park

Hydrotechnical Calculation and Examination of Waste Water Discharge

July 2001

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1.0 Introduction

The Town of Koprivnice prepares an industrial zone for different clients on the eastern border of the town towards Vlcovice. The building is developed and will continue gradually, manufacturing fields are not known, however, it is presupposed that machine and electrical production will prevail.

Waste water will arise from production processes but neither the composition nor the quantity of that are known. The submitted assessment aims at the evaluation of the quality of waste water commonly originated during production processes in respect to the existing state of the streams it will be discharged into after preceding treatment.

Two streams exist in the surroundings of the Industrial Zone of Koprivnice - Vlcovice into which waste water may be discharged. Sykorecek is classified as a small water stream and serves for the discharge of rain and sewage water from the adjacent lands. Lubina is classified as a significant water stream and is administered by Povodi Odry (Odra Water Basin), state enterprise, Ostrava.

The issue of the waste water discharge has to be divided into the following assessments:

A. Waste water discharge into Sykorecek
B. Waste water discharge into Lubina

Every stream has to be assessed taking into account the following points of view:

a) Hydrological data - flows in the stream
b) Ministerial Order no. 82/1999 Coll. setting the indicators and values of allowable water pollution grade
c) Law no.58/1998 Coll. on fee for waste water discharge into surface water
d) Regulation no.47/1999 Coll. enforcing Law no. 58/1998 Coll. on fee for waste water discharge into surface water

2.0 Hydrotechnical assessment

A. Sykorecek Brook

The local Sykorecek Brook flows along the western limit of the Industrial Zone of Koprivnice - Vlcovice taking rain and waste water from the adjacent area including the drainage from the complex Tatra Koprivnice in km 3,350. As well as waste water from the adjacent development of different quality and treated water from the water treatment plant of Tatra Koprivnice in km 2,660 are discharged there. Within the preparation of the industrial zone rain water from part of the complex (eg from the car park) has been discharged to Sykorecek Brook. The channel has not a sufficient capacity for transfer of Q_{100}, locally increased flows go out of the channel.

The administrating authority of Sykorecek, Zemědělská vodohospodárská správa (Agricultural Water authority), territorial office in Novy Jicin, has not agreed with emptying of industrial waste water into this stream because m-daily flows in the stream are low and a sufficient dilution of waste water from the industrial zone with the stream water will not be guaranteed. It states that this ditch is to serve for waste and rain water drainage from the adjacent lands. In spite of it an orientation evaluation of the dependence of drained waste water (quality and quantity) on the flow Q_{355} and its quality has been made.

A.1 Hydrological data – flows in the brook

The Czech Hydrometeorological Institute, Ostrava Branch, has been requested for the determination of m-day discharge in two profiles (they are shown in the attached plan) (originals are deposited with the designer). The data has been developed under CSN 75 1400, classified with Class IV and are as follows:

Sykorecek Brook		
Profile	I	II
No. of hydrological arrangement	2-01-01-138	2-01-01-138
Water basin area A (km^2)	0,23	3,4
Long-term average precipitation depth on water basin P_a (mm)	879	879
Long-term average flow Q_a ($l.s^{-1}$)	3	51

M-daily flows Q_{Md} ($l.s^{-1}$)

M	30	60	90	120	150	180	210	240	270	300	330	**355**	364
Profile I	9	5	4	3	2,5	2	1,5	1	0,8	0,6	0,3	**0,2**	0,1

Profile II	123	81	57	43	33	25	20	15	11	8	5	**2**	0,9

A.2 Assessment under Ministerial Order no. 82/1999 Coll., setting the indicators and values of the allowable water pollution grade

Within the preparation of the Ecological Audit for the Industrial Zone of Vlcovice water samples were taken from Sykorecek Brook. For our assessment sample no. 4 (1582) was used taken under the tributary junction with the rain water drainage from the Tatra complex 50 m far in the direction of the stream.

In addition, indicators of pollution of surface water stated in Annex no. 3 to the Ministerial Order no. 82/1999 Coll. were used. As well allowable values "p" of concentrations were included into the assessment of the discharged water quality for analysing discharged waste water samples for the machine and electrical production stated in already cited Ministerial Order, section B 1.4. (more rigid data were adopted). Selected data are compiled in the following table:

Table no. 1

Indicator	**Symbol**	**Unit**	**Sample no.4 (1582)**	**Values for water works streams**	**Values for other streams**	**Allowable value „p“ for mach. and electr. production**
Biochemical oxygen consumption	BSK_5	$mg.l^{-1}$	4,35	4	8	not determined
Chemical oxygen consumption by dichromate	$CHSK_{Cr}$	$mg.l^{-1}$	---	20	50	300
Annealed solutes	RAS	$mg.l^{-1}$	400	380	820	not determined
Non-dissolved substances	NL	$mg.l^{-1}$	6	not determined	not determined	not determined

Non-polar extractable substances	NEL	$mg.l^{-1}$	<0,05	0,05	0,2	2
Phosphorus total	P_c	$mg.l^{-1}$	---	0,15	0,4	3
Cadmium	Cd	$mg.l^{-1}$	<0,001	0,001	0,005	0,1
Mercury	Hg	$mg.l^{-1}$	<0,0005	0,0005	0,001	0,1

From the above it follows that the Sykorecek water quality is at the level of water streams for water works purposes even if it must be emphasized that quality values of one sample may be considered to be orientation ones only.

The calculation of the relationship between the quality and quantity of discharged water and water quality in the brook is given by the following relation:

$$\mathbf{Q_{ov} \,.\, C_{ov} + Q_t \,.C_t = C_{ov+t}\,(Q_{ov} + Q_t),}$$ where

$\mathbf{Q_{ov}}$ **-** waste water quantity from the pollution source, discharged through a discharged building; maximum water flows based on polluter's input data are introduced (or required by him for incorporation into the water permit) – in $\mathbf{l.s^{-1}}$

$\mathbf{C_{ov}}$ **-** pollution concentration in a given indicator in discharged water; average concentration is introduced and identified as a ratio of the highest required by the polluter hourly discharged pollution and average quantity of discharged waste water– in $\mathbf{mg.l^{-1}}$

$\mathbf{Q_t}$ - water flow in stream; the value Q_{355} is introduced; for water flow profiles where characteristic data affected at present by an artificial intervention a flow set by the water authority within a water permit procedure or within approved handling rules will be used (minimum firm discharge) - in $\mathbf{l.s^{-1}}$

$\mathbf{C_t}$ **-** pollution concentration in a given indicator in water above the point of water discharge from the assessed source of pollution at Q_{355} or minimum firm discharge in stream – v $\mathbf{mg.l^{-1}}$

$\mathbf{C_{ov+t}}$ - pollution concentration of mixed waste water and water in a stream

The following equation was adjusted so that the following known assumed input data may be used:

$$C_{ov} = \frac{Q_{ov+t}\,(Q_{ov} + Q_{355}) - C_t \,.\, Q_{355}}{Q_{ov}}$$, where

Q_{355} - 2 $l.s^{-1}$

C_{ov+t} - 50 $mg.l^{-1}$ (for other water streams)

C_t - 20 $mg.l^{-1}$ (for water works streams)

Q_{ov} - permitted quantity of discharged waste water (10,20, 50,100,200,…00 $l.s^{-1}$)

C_{ov} - calculated pollution concentration in waste water in $mg.l^{-1}$

Table no.2

Pollution indicator	**Quantity of discharged waste water** $Q\ (l.s^{-1})$	**Sykorecek** $Q_{355}\ (l.s^{-1})$	**Concentration of mixed waste water and stream** $C_{ov+t}\ (mg.l^{-1})$	**Concentration of substances in stream** $C_t\ (mg.l^{-1})$	**Calculated concentration of waste water** $C_{op}\ (mg.l^{-1})$
$CHSK_{Cr}$	10	2	50	20	56,0
	20				53,0
	50				51,2
	100				50,6
	200				50,3
	400				50,2
	600				50,1
	800				50,1
RAS	10	2	820	380	908
	20				864
	50				837,6
	100				828,8
	200				824,4
	400				822,2
	600				821,4
	800				821,1
NEL	10	2	0,2	0,05	0,230
	20				0,215
	50				0,206
	100				0,203
	200				0,202
	400				0,2008
	600				0,2005
	800				0,2003
P_c	10	2	0,4	0,15	0,45
	20				0,43
	50				0,41
	100				0,41
	200				0,40

	400				0,40
	600				0,40
	800				0,40
Cd	10	2	0,005	0,001	0,0058
	20				0,0054
	50				0,0052
	100				0,0051
	200				0,0050
	400				0,0050
	600				0,0050
	800				0,0050
Pollution indicator	**Quantity of discharged waste water** **Q ($l.s^{-1}$)**	**Sykorecek** **Q_{355} ($l.s^{-1}$)**	**Concentration of mixed waste water substances and stream C_{ov+t} ($mg.l^{-1}$)**	**Concentration of substances in stream** **C_t ($mg.l^{-1}$)**	**Calculated concentration of waste water** **C_{op} ($mg.l^{-1}$)**
Hg	10	2	0,05	0,005	0,0599
	20				0,0549
	50				0,0519
	100				0,0510
	200				0,0505
	400				0,0502
	600				0,0501
	800				0,0501

The relationship between the quantity of discharged waste water and its calculated concentration and firmly determined flow Q_{355}, flow concentration C_t (free of waste water) and concentration of stream C_{t+ov} including waste water is shown in the graphs:

- Waste water discharge into Sykorecek for $CHSK_{Cr}$ and RAS
- Waste water discharge into Sykorecek for NEL and P_c
- Waste water discharge into Sykorecek for Cd and Hg

From the above graphs and table it is clear that the Sykorecek water quality at very small flow and quality at the level of a water works stream after waste water inflow of the quality of other surface streams belongs to that of other water streams. Any increase in waste water pollution indicators results in an excess of pollution limits set by the Ministerial Order no.82/1999 Coll..

B Lubina River

The Lubina river is a backbone stream of the Beskydy Hills emptying into Odra river between Polanka nad Odrou and Jistebnik. The river belongs to significant water streams and is

administered by Povodi Odry, state enterprise, Ostrava. Lubina is a source of surface water for close industrial plants and as well rain water, waste water from the water treatment plant of municipal and industrial water and non-treated waste water is discharged into it.

For possible discharge of waste water from the Industrial Zone of Koprivnice – Vlcovice M-daily flows in Lubina river has to be known which will be the basis for the calculation of the quantity and quality of emptied waste water.

B.1 Hydrological data – flows in the river

M-daily flows were determined by the Czech Meteorological Institute, Ostrava Branch, in the profile under the stage of Tatra Koprivnice (drawn in the attached site plan). Data has been developed under CSN 75 1400, classified with Class IV and are as follows:

Lubina river	
Profile	Under the stage of Tatra Koprivnice
No. hydrological order	2-01-01-137
Water basin area A (km^2)	114,3
Long-term mean precipitation depth on water basin P_a (mm)	962
Long-term mean flow Q_a ($l.s^{-1}$)	1,38

M-daily flows Q_{Md} ($m^3.s^{-1}$)

M	30	60	90	120	150	180	210	240	270	300	330	**355**	364
Under stage	3,43	2,23	1,64	1,28	1,01	0,816	0,856	0,523	0,407	0,301	0,200	**0,101**	0,039

B.2 Assessment under the Ministerial Order no. 82/1999 Coll. setting indicators and values of the allowable water pollution grade

Within the Ecological Audit for the Industrial Zone of Koprivnice - Vlcovice mean values of water samples taken from Lubina by Povodi Odry, state enterprise, Ostrava has been adopted. Mean values were provided by monitoring in the period 1 – 12/1999 – 5/2000.

In addition, indicators of pollution of surface water stated in Annex no. 3 to the Ministerial Order no. 82/1999 Coll. were used. As well allowable values "p" of concentrations were included into the assessment of the discharged water quality for analysing discharged waste water samples for the machine and electrical production stated in already cited Ministerial Order, section B 1.4. (more rigid data were adopted). Selected data are compiled in the following table:

Table no.3

Indicator	**Symbol**	**Unit**	**Sample no.4 (1582)**	**Values for water works streams**	**Values for other streams**	**Allowable value „p“ for mach. and electr. production**
Biochemical oxygen consumption	BSK_5	$mg.l^{-1}$	2,1	4	8	not determined
Chemical oxygen consumption by dichromate	$CHSK_{Cr}$	$mg.l^{-1}$	11,6	20	50	300
Annealed solutes	RAS	$mg.l^{-1}$	168	380	820	not determined
Non-dissolved substances	NL	$mg.l^{-1}$	13	not determined	not determined	not determined
Non-polar extractable substances	NEL	$mg.l^{-1}$	---	0,05	0,2	2
Phosphorus total	P_c	$mg.l^{-1}$	---	0,15	0,4	3
Cadmium	Cd	$mg.l^{-1}$	---	0,001	0,005	0,1
Mercury	Hg	$mg.l^{-1}$	---	0,0005	0,001	0,1

From the above values it follows that the quality of water in Lubina River is at the level of water quality in water works streams. The above values are a result of a long-term monitoring and may be considered representative..

The calculation of the relationship between the quality and quantity of discharged water and water quality in the river is given by the following relation:

$$Q_{ov} \cdot C_{ov} + Q_t \cdot C_t = C_{ov+t} (Q_{ov} + Q_t)$$

Comments on particular symbols are on page 5.

The following equation has been adjusted so that the following known assumed input data may be applied:

$$C_{ov} = \frac{Q_{ov+t} (Q_{ov} + Q_{355}) - C_t \cdot Q_{355}}{Q_{ov}}$$, kde

Q_{355} - 101 $l.s^{-1}$

C_{ov+t} - 50 $mg.l^{-1}$ (for other water streams)

C_t - 20 $mg.l^{-1}$ (for water works streams)

Q_{ov} - permitted quantity of discharged waste water (10,20, 50,100,200,…00 $l.s^{-1}$)

C_{ov} - calculated pollution concentration in waste water in $mg.l^{-1}$

The results of the calculation are compiled in the following table.

Table no.4

Pollution indicator	**Quantity of discharged waste water** Q **($l.s^{-1}$)**	**Lubina** Q_{355} **($l.s^{-1}$)**	**Concentration of mixed waste water and stream** C_{ov+t} **($mg.l^{-1}$)**	**Concentration of substances in stream** C_t **($mg.l^{-1}$)**	**Calculated concentration of waste water** C_{op} **($mg.l^{-1}$)**
$CHSK_{Cr}$	10	101	50	20	353
	20				201
	50				111
	100				80
	200				65
	400				58
	600				55
	800				54
RAS	10	101	820	380	5264
	20				3292
	50				1809
	100				1314
	200				1067
	400				944
	600				894

	800				876
NEL	10	101	0,2	0,05	1,715
	20				0,957
	50				0,503
	100				0,351
	200				0,276
	400				0,238
	600				0,225
	800				0,219
P_c	10	101	0,4	0,15	2,925
	20				1,663
	50				0,905
	100				0,653
	200				0,526
	400				0,463
	600				0,442
	800				0,432
Pollution indicator	**Quantity of discharged waste water Q ($l.s^{-1}$)**	**Sykorecek Q_{355} ($l.s^{-1}$)**	**Concentration of mixed waste water and stream C_{ov+t} ($mg.l^{-1}$)**	**Concentration of substances in stream C_t ($mg.l^{-1}$)**	**Calculated concentration of waste water C_{op} ($mg.l^{-1}$)**
Cd	10	101	0,005	0,001	0,0454
	20				0,0252
	50				0,0131
	100				0,0090
	200				0,0070
	400				0,0060
	600				0,0057
	800				0,0055
Hg	10	101	0,05	0,005	0,549
	20				0,299
	50				0,149
	100				0,099
	200				0,075
	400				0,062
	600				0,058
	800				0,056

The relationship between the quantity of discharged waste water and its calculated concentration and firmly determined flow Q_{355}, flow concentration C_t (free of waste water) and concentration of stream C_{t+ov} including waste water is shown in the graphs:

- Waste water discharge into Sykorecek for $CHSK_{Cr}$ and RAS
- Waste water discharge into Sykorecek for NEL and P_c
- Waste water discharge into Sykorecek for Cd and Hg

From the table and graphs it is clear that regarding the water bearing it will be better to discharge waste water into Lubina. The river better copes with the discharged pollution and quantity. Carrying out the above calculations we came from the presupposition that the existing river has parameters for a water works stream and the condition for it is that after the

waste water intake the river will not show worse parameters than those determined for other water streams.

Furthermore, it has to be taken into account that different quantities of waste water are placed to different every pollution indicators. The compliance of particular pollution indicators to the discharged waste water quantity must be solved in the technological part of the design. The design must involve as well a proposal for the measurement of quality and quantity of the discharged waste water for process equipment already given.

3.0 Assessment under Law no. 58/1998 Coll. and Regulation no. 47/1999 Coll. on fee for the discharge of surface waste water

In discharging waste water into water streams conditions of Law no.58/1998 Coll. and Regulation no.47/1999 Coll. dealing with setting fees for the excess of pollution indicators of discharged waste water into surface water must be observed. Should waste water be discharged together with rain water into the stream, rain water becomes waste water and should its quantity and pollution exceed determined pollution limits, a fee must be paid. From the above stated it is clear that when implementing new industrial buildings it will be more advantageous for the investor in respect to current laws to operate separate sewage and rain water drainage and industrial waste water drainage in addition to it. Thus the investor will not pay for ballast rain water. It should be emphasized that in calculation of fee for the excess of given limits mass and concentration limits have to be exceeded too.

The following table shows the calculation of waste water quantity the excess of which results in payment based on concentration and mass limits.

Table no. 5

Pollution indicator	**Rate Kc/kg**	**Limit for payment**		**Discharged quantity of waste water l/s**	**Discharged quantity of waste water m^3/rok**
		mass kg/year	**concentration mg/l**		
$CHSK_{Cr}$ – neciš těné	16	20 000	40	15,85	500 000,0

odpadni vody do 31.12.2004					
$CHSK_{Cr}$ – non-treated waste water from 1.1.2005	16	8 000	40	6,34	200 000,0
$CHSK_{Cr}$ – treated waste water	8	10 000	40	7.93	250 000,0
RAS	0,5	20 000	1 200	0,53	16 666,0
Pollution indicator	**Rate Kc/kg**	**Limit for payment**		**Discharged quantity of waste water l/s**	**Discharged quantity of waste water m^3/rok**
		mass kg/year	**concentration mg/l**		
Non-dissolved substances	2	10 000	30	10,57	333 333,0
Phosphor total till 21.12.2004	70	13 000	3	137,41	4 333 333,0
Phosphor total from 1.1.2005	70	3 000	3	31,70	1 000 000,0
Nitrogen N_{anorg} od 1.1.2001	30	20 000	20	31,70	1 000 000,0
AOX od 1.1.2001	300	15	0,2	2,38	75 000,0
Mercury	20 000	0,4	0,002	6,34	200 000,0
Cadmium	4 000	2	0,01	6,34	200 000,0

When discharging waste water into the stream and mass and concentration limits are not exceeded at the same time, the discharged waste water fee will not be paid, if the above values are exceeded, polluted discharged waste water fee will be paid.

4.0 Conclusion

The quantity and quality of waste water to be discharged to the streams cannot be determined in the submitted assessment. By means of graphs and calculations in the tables the limits between which the quality and quantity of waste water may range can be determined. It is

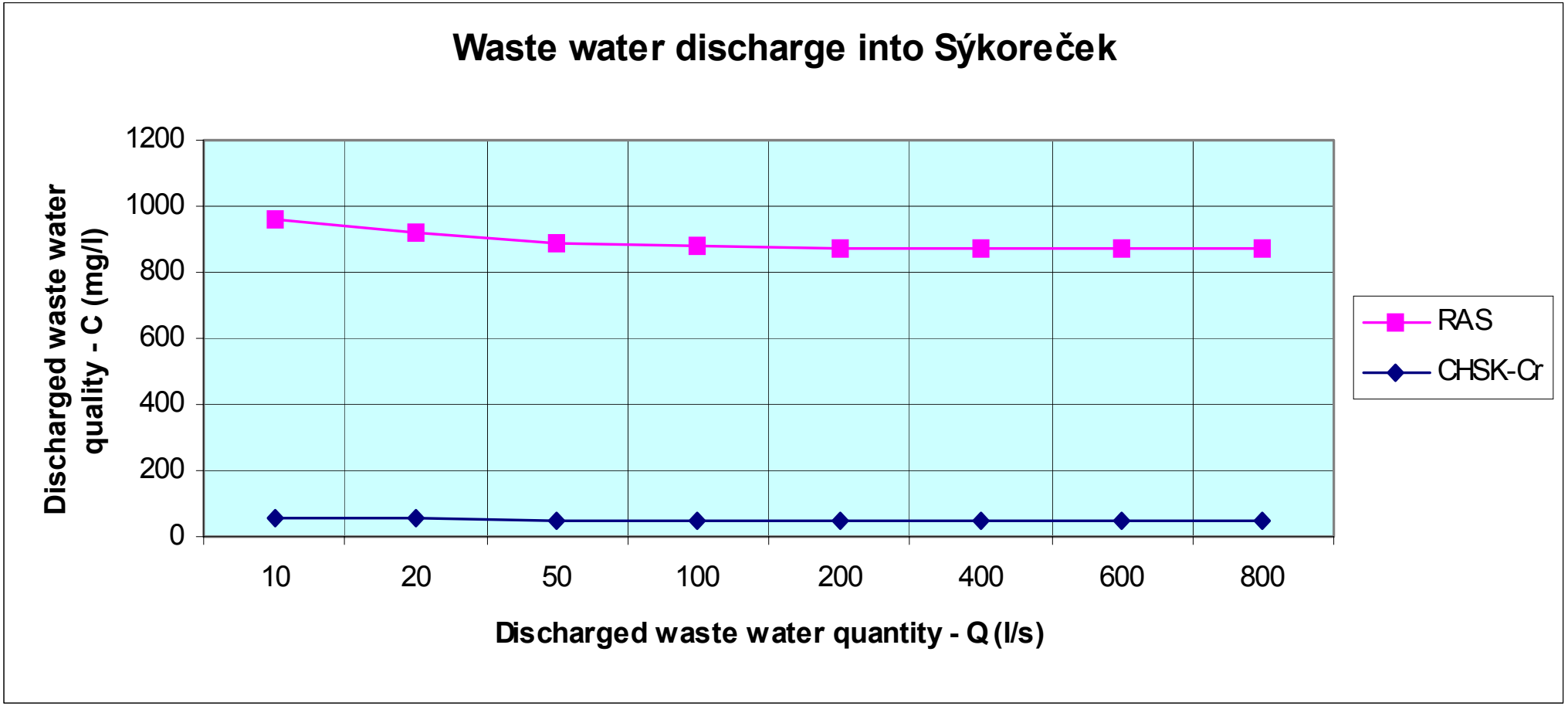
necessary to assess from the ecological and economic viewpoints whether by chance possible fees for waste water discharge are more reasonable to be paid for or expensive process equipment shall be installed. However, in any case, the discharge of waste water into surface water has to be discussed with the stream administrator, hygienic authority and other parties to the procedure appointed by the water authority and even after the decision is made the discharge may be realized.

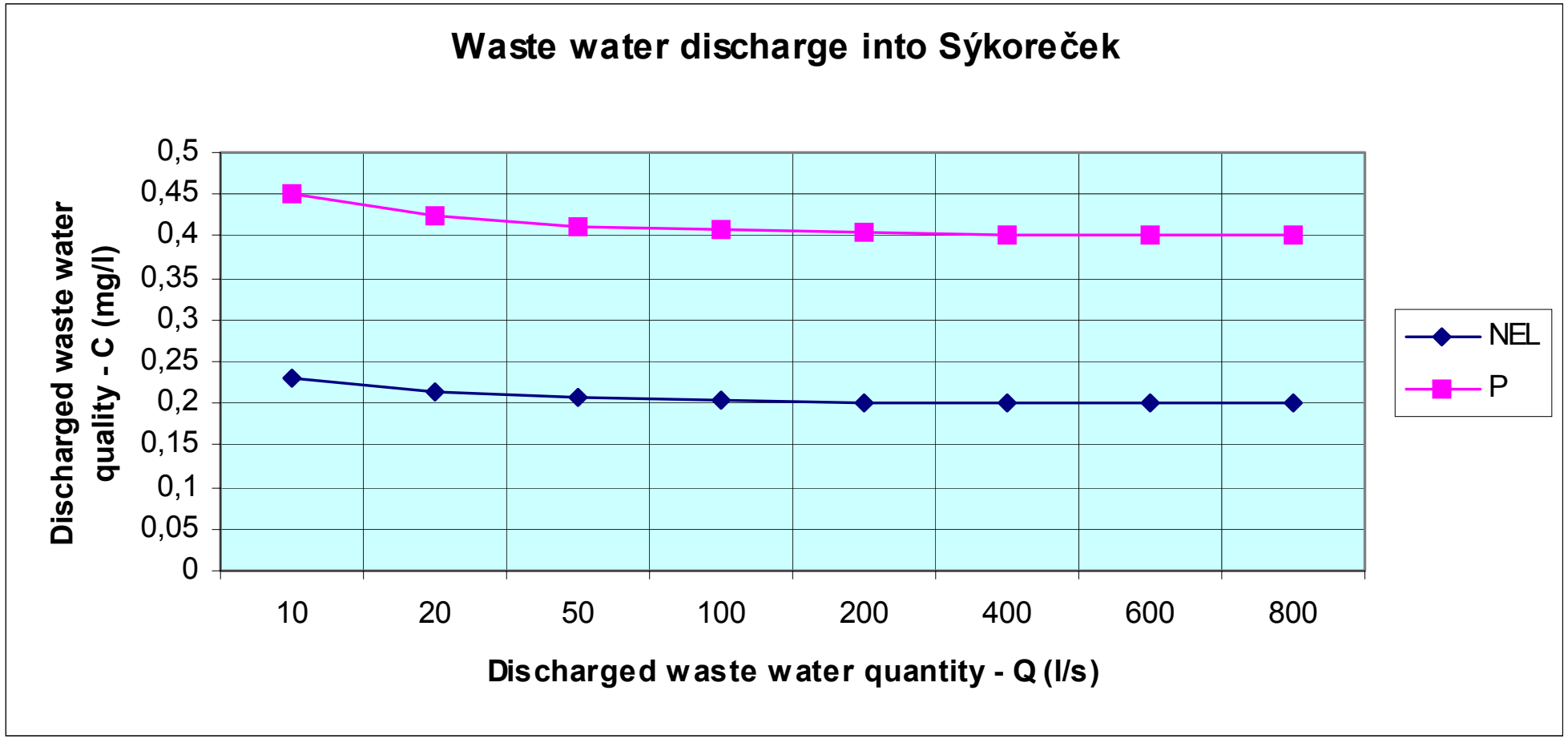
Furthermore, it is necessary to realize that the discharge limits under the Ministerial Order no. 82/1999 Coll. t are maximum and water authority may decrease them if needed by the stream in a given profile.

The whole system of industrial water discharge shall be monitored both from the viewpoint of quality and quantity. The monitoring unit shall be installed on an outlet to the stream where no other intake exists.

If waste water produced by different operators are discharged to the waste water piping, every polluter has to monitor his waste water himself and a key fee rates have to be set before. Of course, the recommendation is to discharge waste water using his own facilities, possible disputes can be preceded in this way.

Ostrava, July 2001 Ing. Šárka Dubová


Waste water discharge into Sýkoreček
Discharged waste water quality - C (mg/l)
1200
1000
800
600
400
200
0
10
20
50
100
200
400
600
800
Discharged waste water quantity - Q (l/s)
RAS
CHSK-Cr


Waste water discharge into Sýkoreček
Discharged waste water quality - C (mg/l)
0,5
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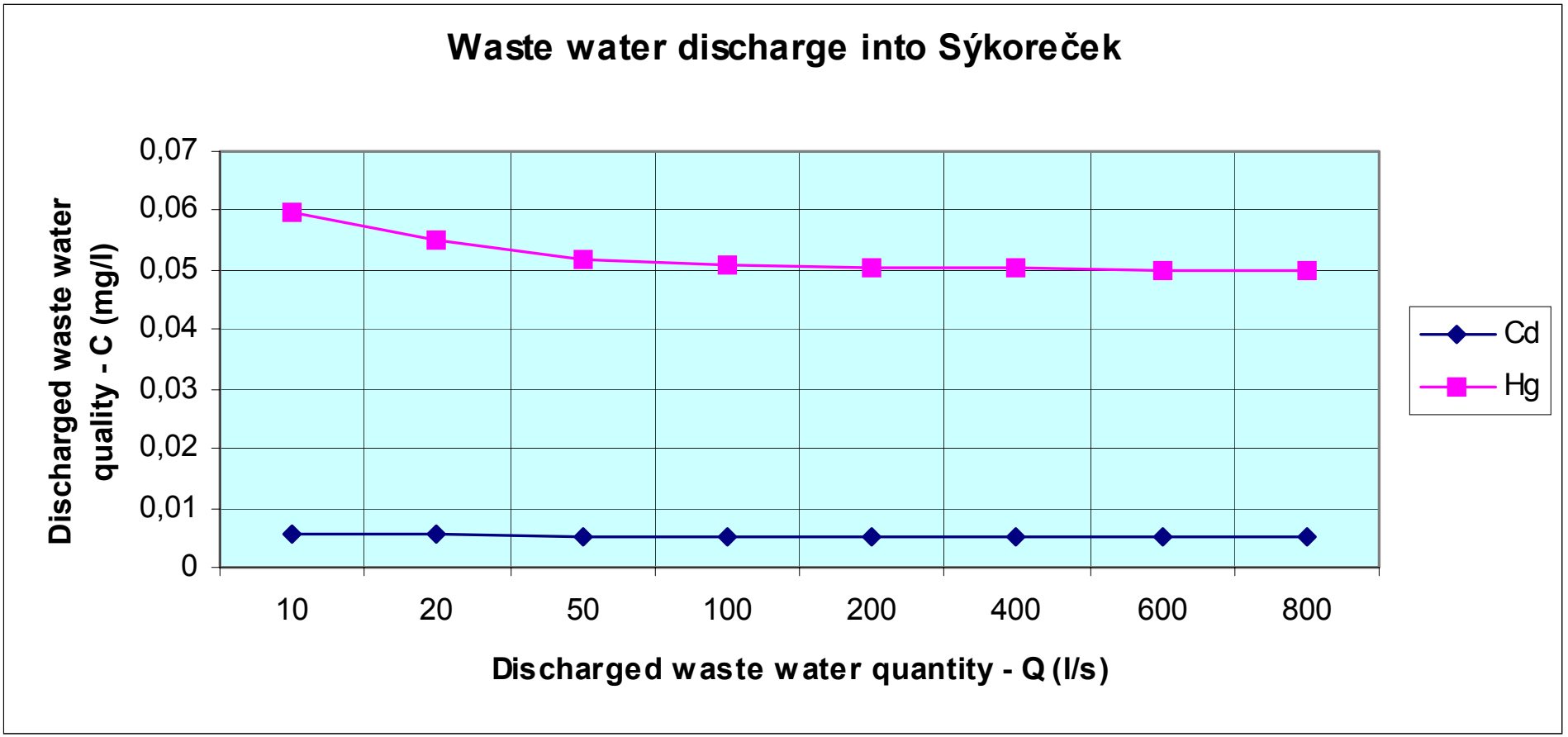
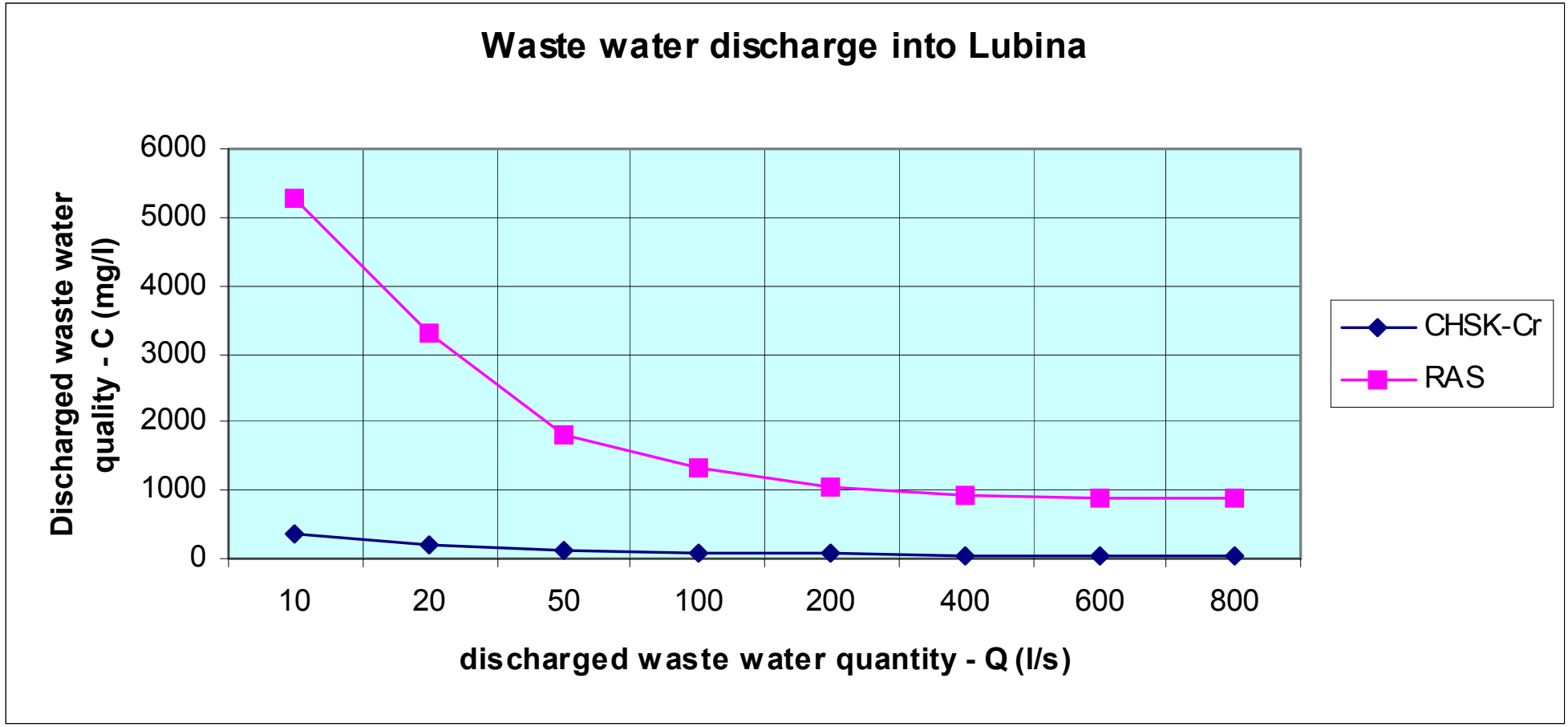
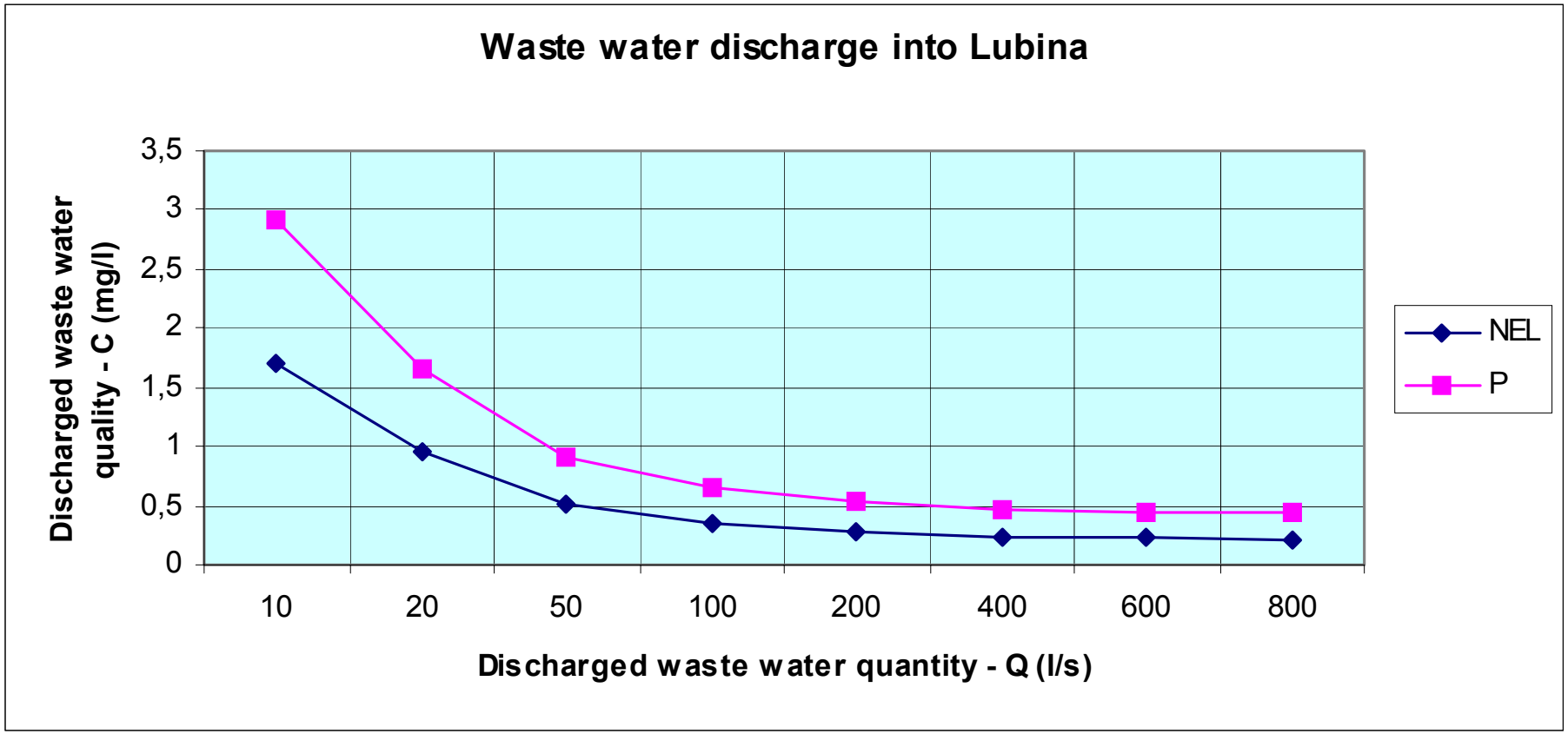
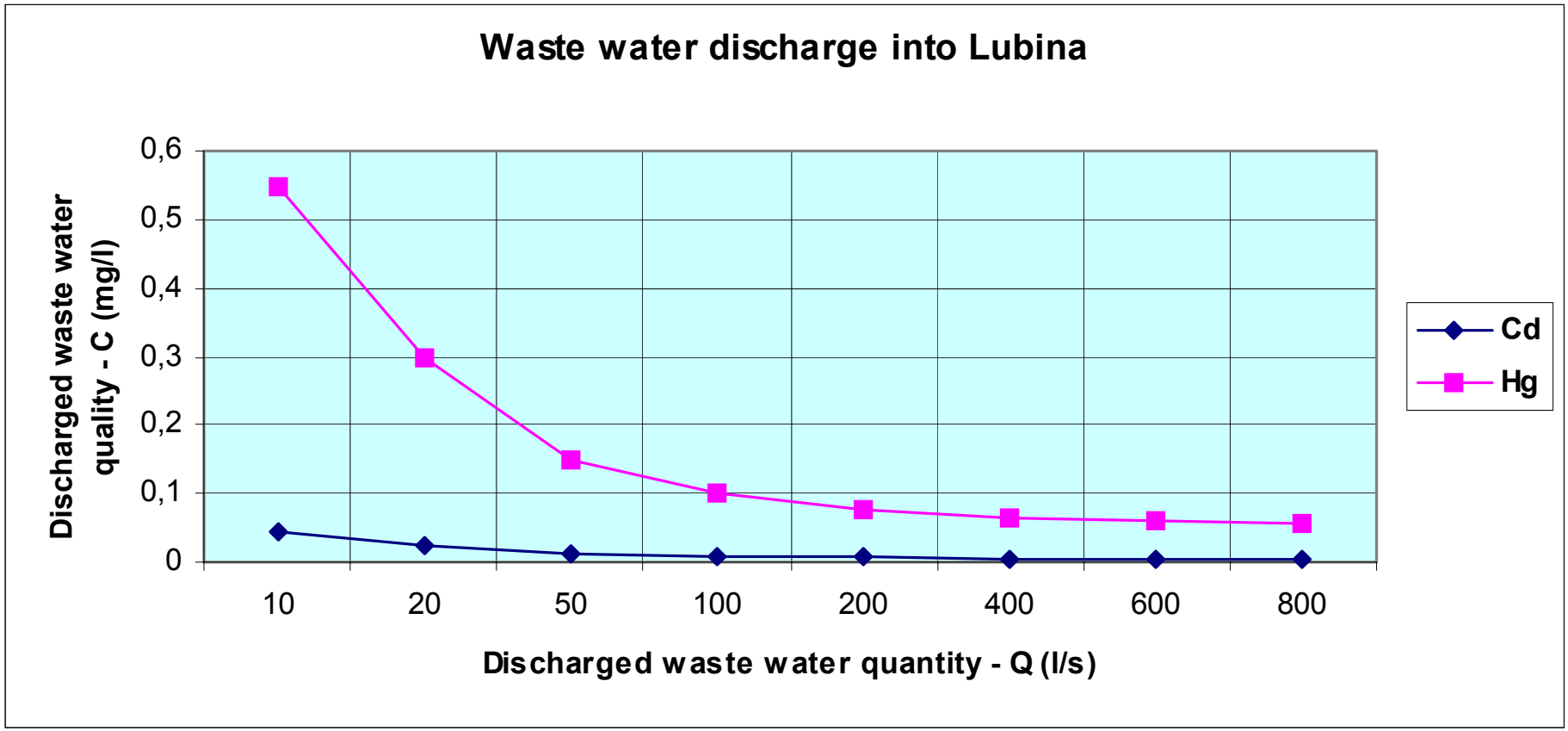
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
10
20
50
100
200
400
600
800
Discharged waste water quantity - Q (l/s)
NEL
P


Waste water discharge into Sýkoreček
Discharged waste water quality - C (mg/l)
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0
10
20
50
100
200
400
600
800
Discharged waste water quantity - Q (l/s)
Cd
Hg


Waste water discharge into Lubina
Discharged waste water quality - C (mg/l)
6000
5000
4000
3000
2000
1000
0
10
20
50
100
200
400
600
800
discharged waste water quantity - Q (l/s)
CHSK-Cr
RAS


Waste water discharge into Lubina
Discharged waste water quality - C (mg/l)
3,5
3
2,5
2
1,5
1
0,5
0
10
20
50
100
200
400
600
800
Discharged waste water quantity - Q (l/s)
NEL
P


Waste water discharge into Lubina
Discharged waste water quality - C (mg/l)
0,6
0,5
0,4
0,3
0,2
0,1
0
10
20
50
100
200
400
600
800
Discharged waste water quantity - Q (l/s)
Cd
Hg