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November 1988

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POLLUTION CONTROL RESEARCH INSTITUTE
HARDWAR
DP/IND/83/008/11-04

Republic of India

EXPERT REPORT *

Prepared for the Government of India
by the United nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

Based on the work of Professor Edward S. KEMPA
Expert in Solid and Liquid Waste Disposal

Backstopping Officer: R.O. Williams, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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Explanatory note: The value of India Rupees during the period of the mission reported /March,1988/ was 12.84 Rps for 1 US Dollar.

Abbreviations:

BHEL - Bharat Heavy Electricals Limited, Hardwar
BOD - Biochemical Oxygen Demand
CST - Capillary Suction Time
HEEP - Heavy Electrical Equipment Plant, Hardwar
ISWA - International Solid Wastes and Public Cleansing Association
PCRI - Pollution Control Research Institute, Hardwar
TPS - Thermal Power Station at HEEP Hardwar
UASB - Upflow anaerobic sludge blanket reactor
WED - Works Engineering Department at HEEP, Hardwar.

A B S T R A C T

This fifth Technical Report describes in details the Expert's activity within the frames of UNDP Project "Pollution Control Research Institute", No. IND/83/008/B/01 and particularly formulated in the Job Description of the Expert in Solid and Liquid Waste Management, DP/IND/83/008/11-04/J 13425 during his f i f t h mission of 31 days in India, as the final part of the split mission of 5 months of duration.

The general Job Description received from UNIDO Head Office, Vienna, has been changed at Hardwar by the Head of the Institute, because of the specific and current needs of the PCRI. The duties in question, have been formulated as follows:

/a/ Work on project initiation report for following technical projects: i/ Anaerobic digestors, ii/ Incineration of waste, iii/ Use of bentonite in wastewater treatment.

/b/ Work on decanted water problem from HEEP, TPS with particular reference to trace metals and hydrocarbons.

/c/ Waste water problems of M/S Bes Shell, Kankhal and finalization of recommendations and treatment scheme.

/d/ Report on management of Ash Disposal from TPS.

/e/ Work on International Conference proposed from 28 November to 2 December, 1968.

/f/ Review of work as per his previous visit report.

Some lectures have been delivered for the new Staff Members. Current consultations were a normal part of the day's work.

Contents

1 INTRODUCTION

The Pollution Control Research Institute develops more and more. Its Staff increased in three years to more than 40 employees and this resulted in several mayor research projects just under study or already finalized. This pays e.g. for a project from the air pollution branch and another one for the Bhatinda TPS - environmental impact assessment.

From the last Expert's being at Hardwar /September,1987/ passed some more months, but one can see, that there is a continuation of previous works /see: the Fourth Technical Report/, although some new problems have been introduced.

The Job Description received from UNIDO /annex No.1a/ had a frame character only and has been replaced at Hardwar by a detailed one, formulated by the Head of PCRI/Annex No 1b/. The scope of Expert's work resulted in extension of the period of Mission by some further days.

A short course in Pollution Control has been delivered for some graduates and freshmen, who started at PCRI. Informal consultations should be considered as a normal part of the Expert's work of the day. These gave the Staff a real opportunity to go into details of the consulted topics.

As in former time, also this period of activity, the Expert estimates as very effective and of a great value for the people of PCRI. Some younger Staff members need still further training - not especially outside the institute, but in the [illegible] of their running work. Such supervision can be done by the [illegible] mission.

Again, and already in this place, the Writer would expose the fine cooperation and understanding with the employees of PCRI in general, and with Professor [illegible], the Head of the Institute, as well as with the Executives as Dr [illegible] and Dr [illegible] in particular. Special thanks are also due to the executive Staff of the Water Department, Dr. [illegible] and Dr. [illegible] for their assistance during preparation of proposals for upgrading the sewage treatment plant.

The Expert acknowledge the assistance of and helpful collaboration with Dr A. Islam SIDFA, Mr. Ramchandran, and Mr Sat Pal from the UNDP Office at Delhi, and Mr Juit, Project Officer, from the UNIDO Head Office, Vienna.

RECOMMENDATIONS

1 The Water Control Lab should be furnished with devices for unit operations and processes, typical for wastewater and sludge treatment.

2 An UASB-Reactor could be installed inside the laboratory and used for anaerobic process testing of concentrated, organic wastewaters.

3 Recommended is the upgrading of the Manipur Oxidation Ponds Plant - not through the enlargement or building of some new ponds, but by exact renovation of the existing ponds only.

4 In specific cases recommended are very simple installations in compliance with the scale of the industrial enterprise and the weight of the problem /e.g. the wastewater treatment plant at M/S Ses Shell or the neutralization tank at [illegible]/.

5 The installation of a pilot unit for solid waste combustion, should be considered very carefully. Needed is a complex infrastructure including a regular supply of some hundreds of kilogrammes per hour of raw wastes and disposal of the combustion residues. Several responsible people will be needed for the proper running of the installation.

3 EXPERT's ACTIVITIES

3.1. Anaerobic digestion - a treatment process for concentrated wastewaters

The problem of anaerobic digestion arose already in October 1985, in time of the first Mission of the Expert /see: 1st Technical Report, p.6/. The Expert did his best to explain the backgrounds of the process when applicated to biodegradation of strong organic /mainly industrial/ wastewaters or to sewage sludge. A lab set was designed as well as suggestions were given, for the establishing of a thermostated multi-digester lab set.

The Expert left at PCRI a project of a digester of some 60 litres capacity, which could be made at place in a BHEL workshop. But all these has not be done so far!

In the 3rd Technical Report /see: para 3.4., page 12/, a bench scale batch feed digester and a continuous feed digester are shown. Also these devices have not been introduced.

The Expert's opinion is, that the APC Lab Staff should initiate the digestion process /initially for staff training only/, with very simple installations and small reactors; later on they could scale up the reactors. Apart from these reservations, discussed have been now the possibilities and conditions for the building of an UASB-Reactor in pilot scale. Such scale allows to carry out more or less technical studies.

Typical parameters of different anaerobic reactors can be summarized as follows:

Parameter	Conventional digester	Contact Reactor	Anaerobic Filter	UASB Reactor
Type of waste	Sewage sludge, farm waste	Organic, concentrated wastes of food-processing industry		
COD, g O_2/m^3	>[illegible]	>[illegible]0000	500-50000	1000-[illegible]000
Load, kg COD/m^3xd	[illegible]	1-5	1-15	[illegible]-1[illegible]
Waste retention time,d	[illegible]	[illegible].5-[illegible]	0.2-3	[illegible].[illegible]-1.5
Solid retention time,d	[illegible]	[illegible]	100	100

Biomass yield, kg/kg $COD_{rem.}$	-	0.03-0.1	0.03-0.1	0.[illegible]
Efficiency, % $COD_{removal}$	30-70	60-90	75-95	80-[illegible]

<u>Example:</u> white beet wastewaters

COD inflow 7,500 g O_2/m^3

COD outflow 800 g O_2/m^3

Process efficiency ~ 90 %

Biomass concentration X = 20 kg SS/m^3

Sludge load 1 kg COD/kg org.SS x d

Tank load 15 kg COD/m^3 x d

Energy consumption 0.073 kWh/kg COD.

From the discussions resulted an UASB-Reactor with the following dimensions: 4.0 m high and 0.3 x 0.15 m square section. Such pilot scale reactor should be fabricated from organic glass in special steel or alu construction frames, to carry out semi-technical studies The reactor must be **thermostated**; located inside the WPC Lab it should be covered by an insulated wooden chamber of a top of 1.5 x 1.5 meters.

Further facilities: wastewater /or sludge/ reservoir with a volume of no less than 0.5 cbm - located on a construction outside the building, but above the water level in the digester, a metering pump, control instruments and connection hoses. For biogas collection - a separate gas holder. The biogas can be either flared or used. [illegible] intention is the initiation of studies on anaerobic digestion with high COD wastewater i.e. distillery spentwash from molasses distillation. COD of spentwash is in the range of 40000 g O_2/m^3. This work is to be carried out as a part of one of the five Project Initiation Reports, proposed for the year 1988-89.

On technological scale, if laboratory experiments will be successful, this particular research is going to be [illegible] as there are number of distilleries all over [illegible], [illegible] treatment facilities.

Main collocutor: Dr. [illegible].

[illegible]. Incineration of solid wastes

Main collocutors: Dr [illegible]. Trehan, Mr. [illegible]

This topic has been proposed by [illegible].
Having the interest to cover more and more problems of the environment protection, discussed has been the possibility of installation of an incinerator /oven/ for combustion of municipal refuse and garbage. The Expert considered with and presented to his collocutors all possible merits and demerits of a such pilot unit. First of all it would be advisable to select the location for the incinerator, then to analyse the material for the input. Secondly, the whole infrastructure should be solved including such details as: selection of the crew who will run the installation for days together, the permanent supply with some hundreds of kilogrammes of sorted refuse and consequently the disposal of ash. Finally, the installation should stand not far from the Institute for better control and supervision. Although the capacity of the installation won't be very high the technical and organizational problems are very complex.

The Expert suggested to get in contact with Professor Janusz [illegible] from the Silesian Technical University at Gliwice, Poland, who designed and exploitated such facilities and who would be interested in cooperation within this particular problem and who could adapt his installations for the Indian conditions. An official letter has been sent to professor [illegible] from [illegible], including further explanations written in Polish by the Expert.
The Expert is, however, not convinced, if this problem is of prime importance for [illegible]. From the other side, such a project could be elaborated in advance, by a team of Polish power engineers guided by Prof. [illegible] in collaboration with prof. [illegible].
[illegible] of an incinerator [illegible] industrial [illegible] will cost much more.

3.3. Bentonite usage in water treatment

Collocutors: Dr. Keshav, Mr. Rajiv Maheshvari

The use of bentonite in the treatment of potable water is well known. Bentonite, a colloidal clay /montmorillonite/ is mainly used as an additional coagulating and sorbing agent which forms with the water impurities /such as turbidity, colour/ heavy and better settleable flocs.

The Wet Chemistry Lab Staff tried to introduce bentonite to treatment processes of different kinds of water as e.g. for the drainage water from HLMP, the reclaimed water from the ash ponds, and for the industrial wastewater generated at the M/S Sea Shell Factory.

Although the dosing in the laboratory was for batch feed samples only the results were in all cases promising. As a coagulation residue, sludge of a very high moisture content is formed. In the technics such sludge is very difficult to dewater mechanically. Water evaporates, however, relatively easy in the open. Therefore, at higher temperatures /which are common under Indian climatic conditions/ and low relative air humudities, natural drying of the sludge is possible. The product can be used in agriculture.

The Wet Chemistry Lab staff has been instructed how to interpret the results and how to use bentonite in further studies. Explained have been two important procedures in sludge testing: the specific resistance to filtration /r/, and the Capillary Suction Time /CST/.

3.4. Decanted water from TPS - with particular reference to trace metals, hydrocarbons and cyanides.

Collocutors: Dr. N.C. Trehan, Mr. R. Maheshvari

This particular problem arises practically each time of the Expert's being at the [illegible], but time by time additional and new points are brought for discussion. This time discussed has been the water composition before and after the ash transport from the TPS to the ash ponds.

The total water flow in the close cycle is ca. [illegible] m^3/h, wherein

added fresh water $\cong$ 50 m^3/h,

recycled used-water from the ash ponds $\cong$ 150 m^3/h.

About 50 m^3/h of the water is lost, what means the amount left in ash ponds for decantation and evaporation. [illegible] and TPS Staff intend to use as "fresh water" in the cycle wastewater generated during the washing process of producer's gases. These washings are yellowish in colour, loaded with phenolic compounds, cyanides, hydrogen sulphide and sulphides.

The schemes of the Process Flow Sheet of TPS, and the old and new TPS ash slurry disposal system are presented on the two next pages.

Results of some analyses which represent the effluents from the Gas Producer Plant are given below.

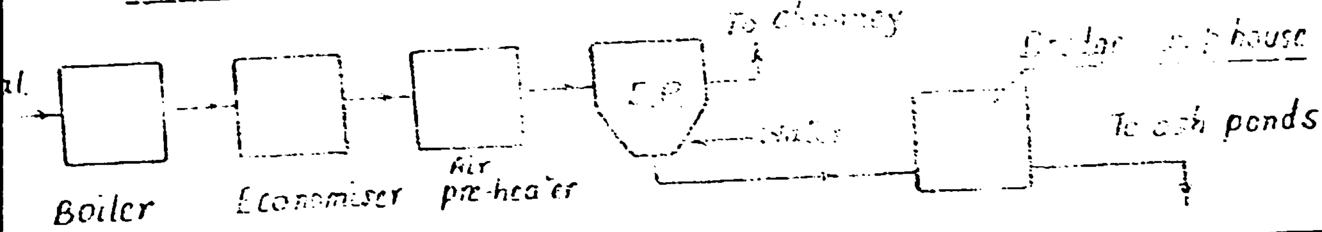
Analyses Nos. 262, 266-270, 274, 275, 282, 284, and 285:

Parameter	Range of values	Arithmetic mean
Reaction, pH	7.15 - 8.67	[illegible].05
Turbidity, NTU	23 - 62	43.5
Suspended Solids, g/m^3	21 - 703	190
Dissolved Solids, g/m^3	152 - 453	322
COD, $g\ O_2/m^3$	16 - 71	32.3
Fluorides, $g\ F^-/m^3$	n.d. - 7.34	5.1[illegible]
Chlorides, $g\ Cl^-/m^3$	11 - 30	[illegible].3
Sulphates, $g\ SO_4^{=}/m^3$	40.8 - 1[illegible].4	7[illegible].4
x Phenols, g/m^3	n.d. - 0.04	[illegible]
x Volatile SS, g/m^3	44.6 - 475	[illegible]
x Volatile DS, g/m^3	94 - [illegible]	114
x Total hardness, $g\ CaCO_3/m^3$	10[illegible] - [illegible]	[illegible]
x Cyanides, $g\ CN^-/m^3$	n.d.	...

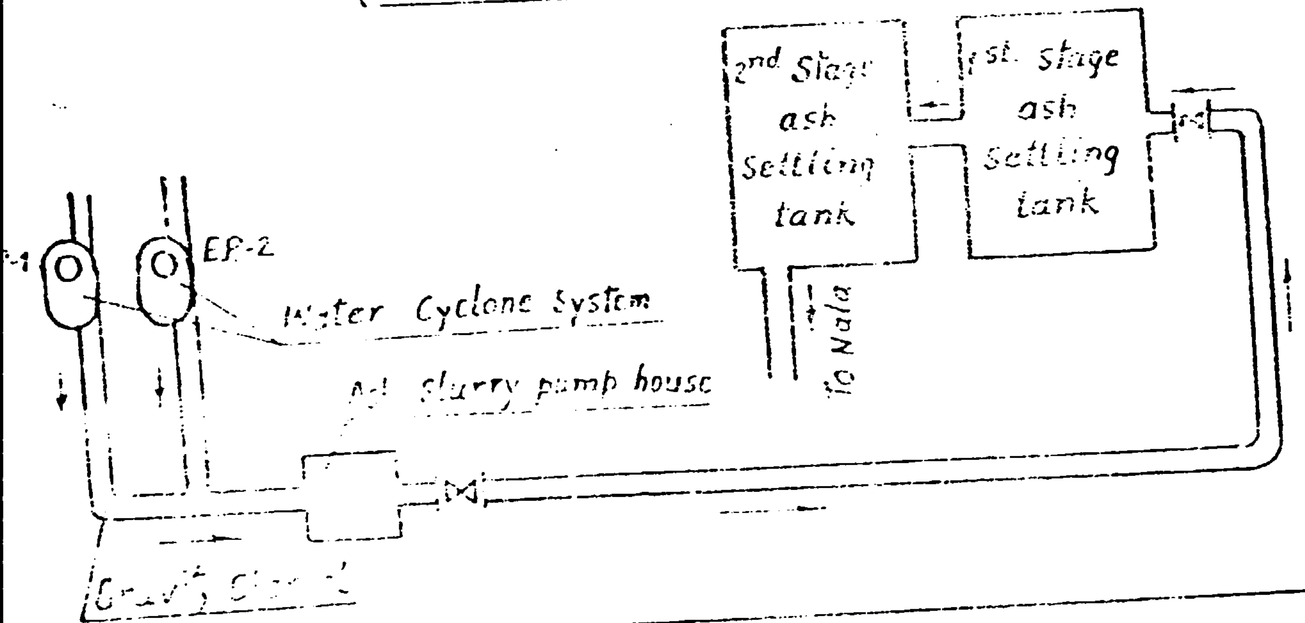
x analysed in [illegible] samples only

The concentration of the specific heavy metals in [illegible] after the decimal point, the total of them below 1 ppm. Such concentrations can be neglected in consideration of pollution control.

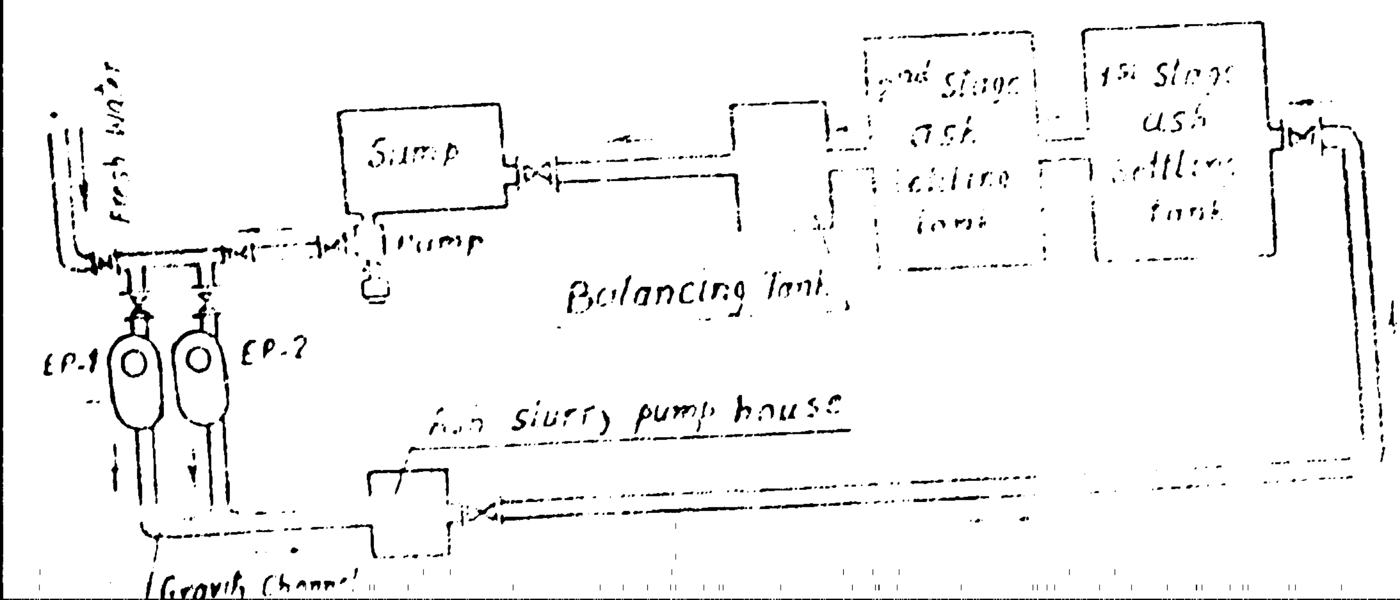
PROCESS FLOW SHEET OF T.P.S.



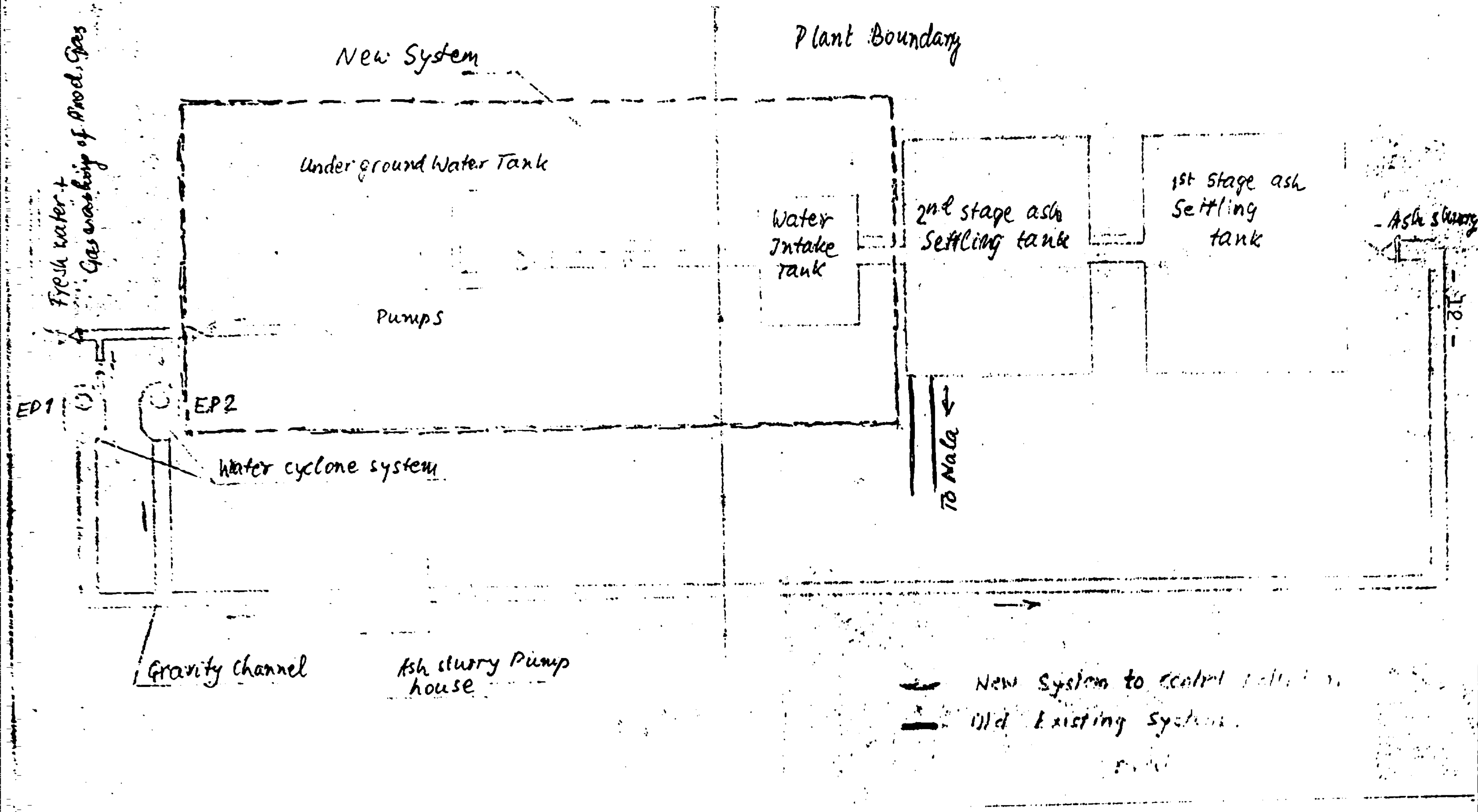
T.P.S. ASH SLURRY DISPOSAL SYSTEM (OLD PRACTICE)



T.P.S. ASH SLURRY DISPOSAL WITH RECIRCULATING SYSTEM (NEW PRACTICE)



POLLU... CONTROL PROJECT FOR ASH ... T.P.S
B.H.E.L. RANIPUR HARDWAR



[illegible]nalyses of Gas [illegible]roducer [illegible]ffluents

Parameter		Mixing Tank T [illegible]	After Settling Tank	Before Settling Tank
Sample No. and date		[illegible] 1[illegible].0[illegible].88	[illegible] 1[illegible].0[illegible].88	[illegible]90 10.0[illegible].88
[illegible]eaction, pH		[illegible].17	[illegible].46	[illegible].55
Turbidity, [illegible]TU		35	45	125
SS	ppm	180	269.3	384
DS	ppm	105	191.3	116
VSS	ppm	165.2	244.3	321.6
COD	$g\ O_2/m^3$	512.2	1177.6	1472
BOD_5	$g\ O_2/m^3$	129	n.determ..	302.35
Oil,grease	ppm	52.33	120.67	708.0
Phenols	ppm	26.04	132.0	34.7
Cyanides	ppm	3.54	22.4	24.3
Sulphides	ppm	16.64	76.40	55.2
Alkalinity	$g\ CaCO_3/m^3$	360	1040	580
NH_3-N	ppm	365	730	590
Total solids, ppm		285	481	500
Redox potential, mV		-26.0	-60.6	-71.0

It is a fact, that the concentrations of pollutants present in the reclaimed water /effluents from the ash ponds/ are, in comparison to the concentrations in the inflow water much lower /sometimes significantly lower/ what means, that the ash particles from the electric precipitators at the TPS act like a sorbent for the dissolved compounds. Most significant is the degradation of the COD - from more than 1000 to some 30-50 mg O_2/litre. The same says for phenols. It can be assumed, that the adsorbed and absorbed pollutants degrade afterwards in the ash ponds during long-term chemical /biochemical, photochemical?/ processes.

Based on the detailed discussions [illegible], the following preliminary suggestions [illegible]:

1/ Producer Gas [illegible] water in the TPS hydraulic ash-transport system.

2/ After longer period of ash storage in the ponds /minimum for several months/ under the given climatic conditions, the typical pollutants such as COD, phenols, cyanides, decrease significantly and the ash becomes a harmless waste.

Before general application of producer gas washings to the system, appropriate and broader studies should be performed for confirmation of this preliminary study reported above.

3.5. Wastewater problem at M/S Sea Shell, Kankhal

Collocutors: Dr. N.C.Trehan, Dr. Keshaw, Dr /Mrs./A.Srivastava - from PCRI,
- the Executives from M/S Sea Shell.

At this factory, a small amount of no more than 2 cbm/d milky /in colour/ wastewater is generated at the production of synthetic latex. The main source of the wastewater is the washing process of the polimerization reactors after the batch production process. Up to the time of problem's consideration, the wastewater was discharged on a nearby forest plot without visible negative effects.

The factory intends, however, to treat the wastewater prior to discharge. Successfully studied has been the application of bentonite /see para 3.3. of this Report/, which resulted in a good clarification of the used-water. Different solutions of a mechanical-chemical treatment were considered. We suggested finally a very simple technological scheme:

- wastewater sink, } inside the building
- pump
- elevated storage tank, with a volume of 1.5 cbm; tank dimensions L x B x H = 1.5 x 1.5 x 1.0 m, effective depth = [illegible] m,
- vertical [illegible] sedimentation tank. D = 1.0 m, H_{eff} = [illegible] m, volume = 1 cbm. Mechanical or pneumatic mixing [illegible]. Hydraulic load = [illegible].1 $m^3/m^2 \cdot h$.
- Over the sedimentation tank a 10-litre glass bottle with solution of bentonite /or another coagulant - if applicable/.

After the consecutive unit operations as: dosing of bentonite - adsorption - precipitation - sedimentation, sludge is disposed of first to simple sand drying beds; afterwards the clear [illegible] wastewater is discharged by gravity to the existing forest plot. Sludge is a useless and harmless waste which can be disposed of to a landfill.

In Expert's opinion, detailed analyses of the treated wastewater should be made: firstly for process optimisation, and secondly for the Pollution Control Authorities, as vouchers of the treatment.

3.6. Ash disposal from TPS

This well known problem was this time connected to a complete other TPS - a plant of MSEB at Khaperkheda, Maharashtra. At this TPS two 210 MW turbines are installed and 10,560 m^3/d water will be used, a.o. for hydraulic transport of ashes from the electro-precipitators. The yearly amount of ash disposed of is 8×10^5 tonnes /within 7000 working hours of the plant per year/. The problem of ash ponds at Khaperkheda is similar to that of the BHEL-TPS at Hardwar, the scale however, is much bigger.

Because of the introductory character, no further action has been initiated this time.

3.7. Neutralisation of lab effluents at [illegible]

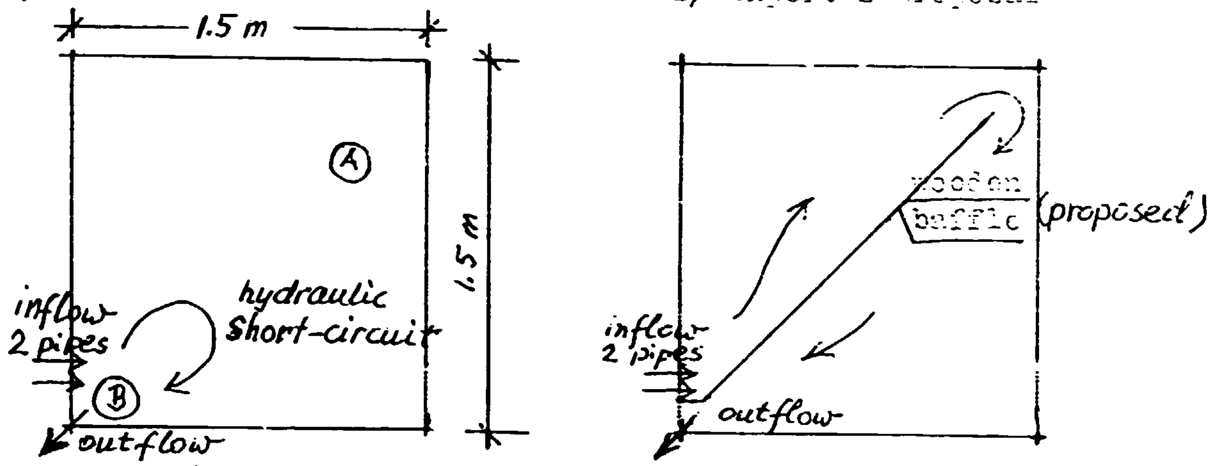
On the main effluent from the Wet Chemistry Lab: the sewer line between the Lab and the septic tank, a neutralisation tank is working. The [illegible] Executives suspected an insufficient neutralisation of the chemical wastes and, in consequence, the improper degradation of organic matter in the septic tank.

The neutralization tank has been, therefore, [illegible]. It has [illegible] with [illegible] -stone [illegible]. There are [illegible] for flow direction. Two inflow [illegible] the outflow are located just nearby in one corner of the tank; this causes in fact the so called hydraulic short-circuits of the [illegible] water flow.

Because of this short-circuit and the big lime-stone lumps, the neutralization is really not sufficient, what have shown some waste-water analyses upstreams and downstreams the tank.

Plan of the neutralization tank

a/ stated situation b/ expert's proposal



The Expert's proposals were as follows:

1/ instal baffle to prevent short-circuits,

2/ crush the lime-stone lumps into 5-6-cm pieces, which will give a much better contact of the stones with sewage. There is no need to exchange the material,

3/ assure regular control of the tank, 2-3 times a year and add some new lime-stone pieces if necessary. At the same time control the chemical composition of the effluent.

3.8. Upgrading of the Sewage Treatment Plant at Manipur

The Expert has been asked to help in modernization and enlargement of the Sewage Treatment Plant at Hardwar-Manipur. The plant in question has been designed in 1966, and probably finished in 196[illegible]. The details of the plant are in Annex No.4.

The Water Works Executives considered the enlargement of the existing plant by reduplication of the oxidation ponds. After recalculation of the whole plant as well as after inspections of the scene, the Expert suggested the departure from the plant enlargement through addition of new ponds. Instead of, the existing ponds should be completely upgraded to the initial form, depth, by furnishing with baffles etc.

In accordance to the present technological views, the ponds should work in series, and therefore, the first pond will serve mainly as a sedimentation tank and a sludge lagoon. After several years /when a sludge layer of about 70 cm will be reached/, the sludge settled in the first pond will be practically mineralised and after removal it can be used at farms as soil conditioner and fertilizer.

3.9. International Conference on Environmental Impact Analysis

The Expert has been asked to review and eventually to correct the PCRI mailing list of the Conference. Furthermore, he enlarged the list by some 50 names of scientists and institutions from his own notebook. These institutions are located mainly in COMECON countries, but some others are also from different countries of the world.

For the Conference in question, the Expert prepared his own abstract on "Impact Analysis of Solid Waste Stockyards on the Environment" for the case he could be at time of this event in India and particularly in Hardwar.

He worked out also a paper on "Influence of Industrial Waste Landfills upon the Soil and Groundwater", which will be presented at the [illegible]'86 Congress, Copenhagen, in Septembe̊r this year /Annex No.[illegible]/.

4 [illegible]S AND UTILIZATION OF THE EXPERT's ACTIVITIES

The Expert's Job Description has been changed because of other central points of activity at PCRI during his mission. The detailed activity is described in para 3 of this report, and the topics were of scientific and engineering art.

1. The anaerobic digestion process was discussed practically during all missions, and the Expert expects that it is [illegible]. It can be finalised when proper lab and pilot units [illegible] reactor [illegible] will be at least installed and [illegible] [illegible] or so.
2. [illegible] better level in the solution of water reclamation [illegible] ponds - at different [illegible], in Hardwar, Bhatinda or [illegible];

besides of generals and similarities noted should be also the local differencies. The same pays for utilization of the ash.

3. Some small problems may have a minor weight for the scientists and for the Institute, e.g. M/S Sea Shell, neutralization tank at [illegible], etc./, but they are important for the owner, and should be solved as well in a proper, engineering manner.

4. The Sewage Oxidation Pond Plant at Kanpur is not well operated; the plant does not need - in the Expert's opinion - any enlargement, but only a proper upgrading, including some changes in the sewage flow through the plant. The thrift of a such solution /given in detailed calculations and drawings/, will be very significant.

5. Occasionally, when discussing different problems with the Wet Chemistry Lab Staff, several analytical and technological procedures have been explained in details. At present these were a.o.:
   - the specific resistance /of sludge/ to filtration /SRF/,
   - the capillary suction time /CST/ of sludge and its relation to [illegible],
   - the putrescibility test for biodegradable sewage, using methylene blue as the indicator. The presence of blue colour means presence of dissolved oxygen and absence of H_2S in the sample.

6. The problem of incineration of refuse only started and will need a longer period for realization with external help /consultation and design of pilot units/.

5 PROGRESS SINCE LAST VISIT

The progress in research and studies since last Expert's visit in September 1988 is significant. Mainly the chemists of the Wet Chemistry Lab became better trained, understanding pretty well the water and wastewater analyses. The same pays for the Staff of the Biological Division.

As an example of a well founded scientific work is the report on

"Environmental Impact Assessment for Thermal Power [illegible] [illegible], [illegible] I-[illegible] [illegible] 1988, 161 pp. and the preprints of [illegible] [illegible] on Pollution in Industrial Environment encompassing 1? pa-pers.

Not all elements and symptoms of progress are measurable and describe-able. Therefore, the Expert can only ascertain, that at present most of the graduates at PCRI are well skilled partners in discussions even in cases when we start from complete different points of view. Advanced training abroad, mainly for the Executives, is still advis-able.

6 CONCLUSIONS

6.1. The Expert's time at PCRI has been fully used by the Staff of the Institute as well as by some other people if it was connected with problems which have to be solved.

6.2. Further scientific help through UNDP/UNIDO experts is still ad-visable, because more complex studies and problems became sub-jects of interest at the Institute.
The specific needs of the PCRI should be a subject of review and discussion of this UNDP-Project by a group of experts. The opportunity for such meeting could be the days before or just after the "International Conference on Environmental Impact Ana-lysis for Developing Countries" which will be held at Delhi from [illegible] November through 2 December, 1988. Such overview should take place at PCRI, Hardwar, for close contact with the PCRI Staff.

6.3. The Expert expects upgrading of the sewage treatment plant after short time; he is sure that his advices given are right both, from the scientific and technical points of view. The quality of [illegible] will meet the Indian Effluent Standards.

Acknowledgements [illegible] already expressed on page 6, here, they are fully [illegible].

Vienna [illegible], April 1988.

Edward J. Kempa, [illegible], DSc.
Professor.

Annex No. 1 a

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO

JOB DESCRIPTION

DP/IND/83/008/11-04/J 13425

Post title Solid and Liquid Waste Management Expert

Duration 4 weeks

Date required February/March 1988

Duty station [illegible]dwar, India

Purpose of project The expert will work in co-operation with the CTA, UNIDO the Government of India, UNDP and BHEL.

Duties Specifically, the expert is requested to

a) work on Bhatinda Thermal Power Station pertaining to monitoring of Soil and Crops in and around Bhatinda T.P.S.;

b) review of work done on the Circulation Scheme of HEEP, BHEL Hardwar;

c) work on environmental impact assessment with respect to Bhatinda project;

d) write a technical report on above work programme.

..../..

Applications and communications regarding this Job Description should be sent to

Project Personnel Recruitment Section, Industrial Operations Division

UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. Box 300, Vienna, Austria

Annex No. 16

NO:PCRI/UNE/83/ [illegible]
Dt: 14th March'1988

Dear Shri Ramachandran,

Sub: Job description for
Prof.E.S.Kempa,UNIDO Expert.

Ref: DP/IND/83/008/11-04/J13425.

Please refer to the job description of Prof. E.S. Kempa for his 4 (four) weeks assignment in our project during March'88. It is requested that following changes in his duties may please be made:-

(a) Work on project initiation report for following technical projects:-

i. Anaerobic digestors.

ii. Incineration of waste.

iii. Use of Bentonite in waste water treatment.

(b) Work on decanted water problem from HEEP, TPS with particular reference to trace metals and hydrocarbons.

(c) Waste water problems of M/S Sea Shell, Kankhal and finalization of recommendations and treatment scheme.

(d) Report on management of Ash Disposal from T.P.S.

(e) Work on International Conference proposed from 28th Nov. to 2nd December'88.

(f) Review of work as per his previous visit report.

With kind regards,

Yours sincerely,

(Prof. S.P. Mahajan)

Mr. M. Ramachandran,
Sr. Programme Officer,
55, Lodi Estate
NEW DELHI

Copy to:-
Prof. E.S. Kempa, UNIDO Expert.

Annex No. 2

T i m e   S c h e d u l e

4 March, 1988 - 4.55 a.m. departure from Zielcna Góra by express train, 10.2o a.m. - arrival at Warsaw

Getting the Visa at the Indian Embassy and air way tickets at the Wagon Lits Bureau, Warsaw

5 March, 1988 - 9.35 a.m. departure by Polish Airlines LOT from Warsaw International Airport to Frankfurt

11.15 a.m. arrival at Frankfurt Airport, FRG,

12.30 p.m. departure by PANAM to Delhi; 2 hrs delay

6 March, 1988 - 3.3o a.m. /two hrs. delay/ arrival at Indira Gandhi International Airport, Delhi. By private taxi to Lodhi Hotel. Sunday - no official work.

7 March, 1988 - 9.oo a.m. Stopover in Delhi and briefing at the UNDP Office. Mr. Sat Pal and Dr M. Islam - the SIDFA- UNDP.

14.oo p.m. departure by car to Hardwar; arrival in Hardwar at 18.3o p.m.

8 March, 1988 - 8.oo a.m. Initiation   the practical work of the Expert. Introduction to the current Institute's problems. Establishment of the new job description by the Head of PCRI Professor S.P. Mahajan. Visit at all Institute's facilities after final removal to the new buildings.

Discussion with Dr. N.C.Trehan on decanted water problem from TPS with particular reference to trace metals, hydrocarbons and cyanides.

9 March, 1988 - Discussion on the used water analyses from TPS /Dr. Trehan, Dr.Ramani, Mr. R. Maheshvari/.

Consultation to the problem of anaerobic sludge digestion - design of lab and pilot scale equipment - Mr. R. Maheshvari.

Afternoon: Visit at the Ranipur Water Works and at the Sewage Treatment Plant /sewage ponds/ - with Dr.N.C.Trehan, Mr.R.Maheshvari and the Water Works Executives.

10 March,1988 - Inspection of water connections and effluents from the Lab building of PCRI.

Discussion on sewage analysis from the PCRI Lab building.

Effluents from the neutralization tank, effluents from the oxidation ponds.

Translation /Dr. Shrivastava/ of volatile matter content and analysis in coal and ash.

Reading the draft report on "Treatment of wastewate by activated bentonite /for the M/S Sea Shell, Kankhal/.

11 March, 1988 - Inspection of wastewater neutralization tank for the effluents from the Lab Chemistry Building.

Discussion of the draft on "Treatment of wastewater by activated bentonite - from the M/S Sea Shell Factory.

Paper writing on the "Impact of Industrial Waste Landfills upon the Soil and Groundwater" - for the ISWA'88 Congress at Copenhagen, September 1988.

12 March, 1988 - First discussion on incineration of waste in a pilo unit. Study's team: Dr. N.C.Trehan, Dr. Keshav, Mr. Sambiah.

Report writing for the first week of present Expert Mission.

Paper writing for the ISWA Congress - cont.

13 March, 1988 - Sunday, no official work.

14 March, 1988 - Final preparation of the paper on "Impact of Industrial Waste Landfills upon the Soil and Groundwater - typesetting on computer

15 March, 1988 - Ranipur Wastewater Plant /Oxidation Ponds/ - with Mr Maheshvari. Determination of some constituents in sewage - discussion with the ChemLab Staff.

16 March, 1988 - Determination of constituents in wastewater from TPS, sludge and ash analysis.

Detailed discussion on a pilot UASB-Reactor and draft calculation of the unit.

17 March, 1988 - Visit at the Water Works Section and Thermal Power plant /TPS/ of BHEL.

Calculation of oxidation ponds.

18 March, 1988 - Reviewing the wastewater analyses of the oxidation ponds effluent. Proposals for a pilot unit and

technical solution of the M/S Sea Shell Plant at Kankhal.

Calculations of oxidation ponds - cont.

19 March, 1988 - Reviewing the sewage analyses of the oxidation ponds. Preparation of a mailing list of professionalists - for the planned PCRI Conference in November, December, 1988 at Delhi.

Preparation of my own abstract for the mentioned Conference. Titel: "Impact Analysis of Solid Waste Stockyards on the Environment"

20 March, 1988 - Sunday, no official work

21 March, 1988 - Oxidation ponds at Ranipur, meeting with the Water Works Executives

After noon: Lectures on Environment Pollution Control for the new employees

22 March, 1988 - Oxidation ponds re-design and proposals for modernization.
Preparation of further lectures on Environment Pollution Control.

23 March, 1988 - Preparation of lectures /continuation/, draft of the Technical Report

Discussion with Mr A.K.Gupta, Manager, on Conference topics,

after noon: Lectures on EPC /cont./

24 March, 1988 - Discussion with the Head of PCRI, Professor S. P. Mahajan on the just realized project consultation acc. to the new Job Description

Discussion on the details in construction of the UASB-Reactor in Pilot scale /Mr. R. Maheshvari/

Visit at the M/S Sea Shell, Kankhal /Dr.N.C.Trehan, Dr. Keshav/.

25 March, 1988 - New TPS and ash ponds at Khaperkheda, Maharashtra /10560 m^3/d/ - Mr. R. Maheshvari. Discussion with the Technological Lab Staff Members on the specific resistance of sludges to filtration and on the capillary suction time /CST/ - both parameters are used in the technological sludge analysis.

26 March, 1988 - Final calculation of the oxidation ponds after modernization. Drawing of the proposals onto the

plans the treatment plant.

27 March, 1988 - Sunday, no official work

28 March, 1988 - Final review of the Expert's work /studies, problems, projects/ with the specific groups of the PCRI Staff

29 March, 1988 - Final review of the Expert's work - continuation. Discussion with Mr. A.K.Gupta, Manager, and Dr.N. C. Trehan,

After noon: departure for Delhi by a car rented by PCRI

30 March, 1988 - 2.3o a.m. departure from Delhi International Airport to Frankfurt,

7.2o a.m. arrival at Frankfurt Airport,

8.4o a.m. departure to Vienna,

10.2o a.m. arrival at Vienna Airport. Lufthansa had lost one piece of my luggage. Waiting for some six hours more for this lost suitcase. Accomodation at the hotel at 5.oo p.m.

31 March, 1988 - Debriefing at the UNIDO Headquarter: Mr. M. Judt and Dr. S. Maltesou, Professor Bisvas.

1 April, 1988 - 11.3o a.m. departure by plane from Vienna airport,

12.4o p.m. arrival at the airport of Warsaw,

16.45 p.m. departure from Warsaw by express train,

22.04 p.m. arrival at Zielona Góra.

2.04. - 8.04. Writing the 5th Technical Report and formal termination of the Mission.

M A T E R I A L S   L E F T

as photocopies:

1 Part V of Professor Meinck's book on "Industrial Wastewater", dealing with the toxicological impact of some wastewater components on plants and animals /F.Meinck: Industrie-Abwässer, Gustav Fischer Verlag, Stuttgart 1968, pp.632-694, in German/

2 Report of the Scientific Advisory Panel on Groundwater Recharge with Reclaimed Wastewater, November 1987, Chapter VII: Managemen and Reliability

3 Potentially Toxic Microorganic Substances in Drinking Water. Report on a Consultation, WHO Regional Office for Europe, EUR/ ICP/CWS 013 5747i, EUR/HFA target 20, 1987

4 G.Lindh: Scenarios for the preparation of guidance and audio-visual material for planners and decision-makers, Techn. Documents in Hydrology, UNESCO Paris 1986

5 Das Bhopal-Unglueck im Dezember 1984. Kurzanlayse, Bewertungen, Schlussfolgerungen für die BRD, Texte 8/87, Umweltbundesamt Berlin 1987

6 Manuscripts of Proceedings of the 3rd International CEC Symposiu on "Processing and Use of Sewage Sludge", Brighton, 27-30 September 1983, and therein:

a/ A.Cottenie, L.Kiekens, and G.van Landschoot: Problems of the Mobility and Predictability of Heavy Metal Uptake by Plants,

b/ W.Kampe: Cd and Pb in the Consumption of Foodstuffs depending on various contents of heavy metals,

c/ R.D.Davis: Crop Uptake of Metals Cd, Pb, Hg, Cu, Ni, Zn, and Cr from Sludge-treated soil and its implication for soil Fertility and for the human Diet,

d/ T.H.Christensen and J.C.Tjell: Interpretation of Experimental Results on Cadmium Crop Uptake from Sewage Sludge amended Soil,

e/ M.D.Webber, A.Kloke and J.C.Tjell: A Review of Current Sludge Use Guidelines for the Control of Heavy Metal Contamination in Soils,

f/ L.Kiekens, and A.Cotterie: Report on the Results of the Inter laboratory Comparison: Determination of the Mobility of Heavy Metals in Soils,

g/ J.N.Lester: Presence of Organic Micropollutants in Sewage Sludge, h/ G.Guidi, and J.E.Hall: Effects of Sewage Sludge on the physical and chemical Properties of Soil,

i/ H.Häni, and S.Gupta: Choice of an Extractant for simulating the Availability and Absorption of Heavy Metals by Plants,

j/ H.Kuntze, E.Pluquet, J.H.Stark, and S.Coppola: Current Techniques for the Evaluation of Metal Problems due to Sludge,

k/ B.J.Alloway, and A.R.Tills: Speciation of Metals in Sludge amended soils in Relation to Potential Uptake,

7 B.H.Dieterich, J.M.Henderson: Urban Water Supply Conditions and Needs in seventy-five Developing Countries, WHO Geneva 1963, Public Health Papers 23

8 M.Korczak, Sz.Koziarski: Biochemical Reactors for Laboratory Studies /4 pages/

9 The Langelier's nomogramme of the bi-carbonate and free CO_2 balance in natural waters

10 4 tables with Quality Standards for feed and boiler waters - from different sources.

A stock of leaflets and information materials on different laboratory equipments.

Professor Edward S.Kempa
UNIDO Expert

Annex No. 4

Oxidation ponds at Hardwar-Jwalapur

Present situation and proposals for upgrading

I. Design of the year 1966

Four ponds have been built having the main dimensions as follows:

$$4 \times /L \times W \times H/ = 4 \times /160 \times 100 \times 1.15/ \text{ m}$$

The surface area is, therefore

$$A = 4 \times 160 \times 100 = 64,000 \text{ m}^2,$$

and the theoretical volume

$$V = A \times H = 64,000 \times 1.15 = 73,600 \text{ m}^3.$$

The total daily sewage flow /as given by the Water Works Executives/ is

$$\underline{\underline{Q_d \cong 14,000 \text{ m}^3/\text{d}.}}$$

Theoretical detention time /theoretical means in this case that all ponds are in operation at the designed depth H, there is no sludge deposit in the ponds, and finally, there are no hydraulic short-circuits inside the ponds/ should be:

$$t_{th} = \frac{V}{Q_d} = \frac{73,600}{14,000} = 5.26 \text{ d} = 5 \text{ d } 6 \text{ hrs.}$$

The present situation differs somewhat from the design:

1/ only three ponds are in operation, the fourth one is fed from a separate pumping station;

2/ the operation depth of the oxidation ponds $/H_p/$ is no more than 0.70 m;

3/ in the internal wall between pond No. 2 and pond No.3 a connection channel has been made;

4/ about 50% of the sewage flows now directly to the farms for irrigation, without any treatment.

Assuming that nowadays only three ponds are working, at a reduced depth of 0.70 m, the present detention time /as [illegible] [illegible] [illegible]tical/ is:

$$t_{th} = \frac{3 \times 160 \times 100 \times 0.70}{0.5 \times 14,000} \approx 4.8 \text{ d} = 4 \text{ d } 19 \text{ hrs.}$$

visit was made to the ponds on 9 March, 198[illegible] with the Executives of the Water Works Division, and samples of sewage taken for analyses in the [illegible] Lab.

After completion of the analytical results, a general calculation of the ponds' efficiency gave the following data:

efficiency in BOD_5 terms $\approx 60\%$,

efficiency in COD terms $\approx 66\%$,

efficiency in SS terms $\approx 56\%$.

These analytical results cannot be generalized as they have been get from one sewage uptake only. In the Expert's opinion /based a.o. on the visuable conditions of the sewage/, the total efficiency of the treatment plant should be assumed and is in fact higher, particularly in SS and BOD_5 terms. Analyses of the sewage, taken up at different points of the ponds, should be repeated several times.

The Water Works Authority is considering the enlargement of the existing ponds twice, what means, that another surface and volume as it exists, should be added:

$A = 64,000 \times 2,$

$V = 73,600 \times 2.$

II. Recalculation of the ponds and Expert's proposals

Calculation of the BOD_5-Load:

Assumed has been /as for Indian conditions/ a unit-load of

0.050 kg BOD_5/cap x d.

Assumed has been the served population of some 30,000 people.

The daily load is, therefore:

= population x unit load =

= 30,000 x 0.05 = 1500 kg BOD_5/d.

[illegible] of raw sewage /acc. to the [illegible] above/ [illegible]:

$$[illegible] = \frac{1500 \times 1000}{14,000} = 107 \text{ g } BOD_5/m^2.$$

This value comes close to the BOD_5 found in the samples analysed. Assumed can be, as for these general calculations, a $BOD_5 \cong 100$ g/m³.

G e n e r a l s /after Metcalf and Eddy: "Wastewater Engineering"/:
Considered are only summer conditions and higher sewage temperatures:

- groundwater temperature at Ranipur /which comes close to the average temperature / is $\sim 24^{o}C$,
- measured sewage temperature $24.5^{o}C$.

At a plug flow, the dispersion factor d = 0.
Assume d = 0.1 for which the product kxt /from a table/ = 2.8.
Taking into account the temperature factor /$T = 32^{o}C$/ for summer conditions

$$k_{32} = 0.25 \; /1.06/^{32-20} = 0.5$$
$$0.5 \times t = 2.8,$$

Expected detention time

$$t = \frac{2.8}{0.5} = 5.6 \text{ d.}$$

The desired volume of the ponds:

$$V = 5.6 \times Q_d = 5.6 \times 14{,}000 = 78{,}400 \text{ m}^3$$

available volume = 73,600 m³

volume deficite 4,800 m³ = 6.1 %.

Such a deficite is acceptable.

Loadings of sewage ponds /acc. to Metcalf and Eddy/:

Type of pond	load, g/m^2d /in terms of BOD/
anaerobic	22 - 56
aerobic-anaerobic	1.7 - 5.6
aerobic, aerated by mixing	6.7 - 13.4

The expected BOD_5 conversion factor is 80-95%. Algal concentration in the effluent 40-160 mg/l.

[illegible]:

/a/ [illegible] operate the oxidation ponds in series, [illegible] flow;

/b/ [illegible] the effective depth of the ponds to the [illegible] of 1.15 m [illegible] probably after cleaning the ponds bottom and removal the sludge deposits in ponds Nos. 2,3 and 4. In pond No.1 not necessary/;

/3/ Collect all streams of the inflow sewage to the plant in one point, so that only the first pond would be fed with raw liquid;

/4/ Modernise at the inflow site the distribution of sewage - see the plans of the ponds with Expert's proposals;

/5/ Re-designed should be the flow-through from one pond to the next one;

/6/ The effluent from pond No.4 should be <u>reconstructed</u> to the same form as it was in the previous project. It means a thin layer effluent through an overflow channel /see plan/.

After these proposed reconstructions:

<u>Pond No.1</u> will work as a sedimentation pond, anaerobic in art, with partial methane digestion of the deposited sludge, but under natural conditions. The sludge layer can arises to some 0.80 m or so, and such layer will be formed after some years of pond operation.

<u>Pond No.2</u> will be a facultative one, with the rest of sediments bio-degraded anaerobically at the pond's bottom.

<u>Ponds Nos. 3 and 4</u> will be strong aerobic.

At normal time and operation, all four ponds will work in series. If pond No.1 should be closed for sludge drying and final removal, only the three other ponds will work, whereas pond No.2 will take over the role of the sedimentation lagoon for this transient period of - let say - 3 to 4 months. The expected efficiency of the total plant will be at that time somewhat [illegible].

<u>[illegible] of the ponds:</u>

[illegible] : [illegible], [illegible] m /[illegible],

[illegible] 100 g BOD/m³.

Pond No.1 /settling of SS, anaerobic conditions/:

$$\text{Detention time } t = \frac{L \times W \times H}{Q_d} = \frac{160 \times 100 \times 1.15}{14{,}000} = 1.3\ d = 1\ d\ 8\ hrs.$$

After years of operation:

$$t_{minim} = \frac{160 \times 100 \times 0.35}{14{,}000} = 0.4\ d = 9.6\ hrs$$

which is still sufficient for sedimentation of settleable solids.

Organic load in this particular pond /in BOD terms/:

$$L = \frac{0.100 \times Q_d}{A_1} = \frac{0.100 \times 14{,}000}{160 \times 100} = 0.0875\ kg\ O_2/m^2\ d.$$

Such organic surface load is higher than that given by Metcalf and Eddy, but in the Expert's opinion it is still acceptable because the sewage must pass three ponds more for further biodegradation. The assumed biodegradation rate can be 25% of the inflow load. The concentration in the effluent will be ca. 75 g BOD_5/m^3.

Ponds Nos.2, 3 and 4

Total load in BOD_5 terms = 0.075 x 14,000 = 1,050 kg O_2/d.

Total area of ponds: 3 x 160 x 100 = 48,000 m^2.

Unit organic load /as an average for all ponds/:

$$\frac{1050 \times 1000}{48{,}000} = 21.875 \approx 22\ g\ O_2/m^2\ d.$$

This loading /acc. to Metcalf and Eddy/, seems to be somewhat higher than in the literature, but the total efficiency in BOD term should be calculated for each pond separately.

Let's assume an efficiency of 65% in each pond only.

Pond No.2:

$$L_{in} = 1050\ kg\ O_2/d$$
$$L_{out} = 1050 \times 0.35 = 367.5\ kg\ O_2/d$$

Pond No.3:

$$L_{in} = 367.5\ kg\ O_2/d$$
$$L_{out} = 367.5 \times 0.35 = \text{[illegible]}\ kg\ O_2/d$$

Pond No.4:

$$L_{in} = \text{[illegible]}\ kg\ O_2/d$$
$$L_{out} = \text{[illegible]} \times 0.35 = \text{[illegible]}$$

[illegible] biodegraded:

$$[illegible] + 60.8 + [illegible].83 + 63.61 = 135[illegible]\ kg\ O_2/d,$$

total [illegible] efficiency

$$\eta_b = \frac{[illegible]}{14[illegible]} \times 100 = [illegible],[illegible]\ \%.$$

[illegible]pected [illegible]-concentration in the effluent $\approx$ [illegible] g O_2/m^3.

Assuming only an efficiency η_b of some 90%, the effluent BOD_5 would be

≤ 10 g O_2/m^3 as dissolved organics, although some of the technologists add 3 ÷ 4 g of BOD_5 for each 10 grams of SS in the effluent sewage.

At present, the ponds do not operate in the proposed manner, the calculated detention time does not be equal to the real detention time and this gives an effluent of ~ 20 g BOD_5/m^3 and an efficiency of about 80%. The proposed scheme should give, when realized, much better results and an effluent BOD_5 of ≤ 10 mg/l can be really expected.

- o - 0 - o -

The Expert reserves the right to calculate the ponds again, but he does not expect, that major changes in the main concept will be necessary. Constructional proposals are on the plans, marked with red colour. The plans have been handed over to the Executives of Water Works.

UNIDO Expert
26 March, 1988

N.B. A seepage channel should be made around the ponds to collect the percolating waters. The bottom of the channel should be made 1-[illegible] feet below the bottom of the ponds. The laterals of drainage pipes /∅ 100 mm in a distance of ~5÷7 m between them/ should be connected to the main channel.

PCRI/TL/88/
Dated: 22.3.1988
23

MINUTES OF MEETING ON OXIDATION PONDS MODIFICATION, HELD ON 21.3.1988 (10.45 AM)

Attended by:-

1. Dr. E.S. Kempa
2. Mr. S.N. Mishra
3. Mr. Verma
4. Dr. N.C. Trehan.
5. Mr. R. Maheshwari.

Following points were discussed & decided:-

1. Analysis results of samples collected from oxidation ponds with performance point of view are satisfactory. However, only a fraction of wastewater (~50%) is used in oxidation ponds and rest is used directly for irrigation in BBG form. If all the wastewater is led through oxidation ponds, problems are likely to be encountered and these may give poor performance. Hence it is necessary to modify and reconstruct the existing ponds to give optimum performance.

2. Major modifications were suggested by Dr. Kempa as given below:-
(a) The ponds should be operated in series.
(b) All wastewaters -industrial and domestic should be collected at one place and them distributed in the first pond.
(c) Inlet and outlet arrangements for all the ponds need to be modified, to avoid hydraulic short circuits.
(d) Seepage from ponds should be collected in a channel built around oxidation ponds. This water can be used for irrigation directly.
(e) Planned should be a long time operation of all four ponds. The first will work first of all as a sedimentation tank for settleable solids and as a sludge lagoon. After some years of operation (e.g. 5 to 8 years) this first pond should be closed, the sludge after dewatering under natural condition removed and used as soil conditioner. For this time, roughly some months, the second pond will play the role of a settling tank. After that period the plant should be operated as previously.

3. Mr. Mishra was requested to give two sets of new drawing so that Dr. Kempa could work out and depict the necessary changes in the oxidation ponds.

4. Dr. Kempa suggested another visit to oxidation ponds on 23.3.88, before finalizing the modifications in it.

(Dr. N.C. Trehan)
Sr. Scientific Officer
(PCRI)

C.C.:-
1- Dr. E.S. Kempa,
2- Head/Manager (PCRI)
3- All members present.

NCTrehan 22/3/88
Sr. S.O. (PCRI)

INFLUENCE OF INDUSTRIAL WASTE LANDFILLS UPON THE SOIL AND GROUNDWATER

A.Jędrczak, E.S.Kempa
College of Engineering, 65-246 Zielona Gora, Poland

INTRODUCTION

The storage of solid waste on ground, although most often in use (~95% of all waste generated in global scale), inspires more and more anxiety. The impact of the landfills reveals in pollution of the surrounding environment, i.e. in pollution of ground- and surface waters, of soil and air. The symptoms of impact are: a change of pH values in water and soil, the increase in soil salinity, higher concentration of micro- and macroelements; sometimes the pollution is manifested by substances normally not present in the nature.

The paper discusses the impact on the environment of two selected storage yards supplied mainly with industrial wastes and studied by the Authors for many years. The first of the stockyards in question has been located under favourable hydrogeological conditions (K=0.1-1 m/d), but it is not properly operated; the second is directly adjacent to the groundwater layer.

DESCRIPTION OF THE STOCKYARDS & SCOPE OF STUDY

First Case Study

The storage yard with an area of 0.05 square km is located in a local cavity. The volume of industrial wastes and municipal refuse which is tipped of there every year, amounts to 124,000 cbm and 21,000 cbm, respectively. Sludges and deposits from electroplating shops, paint and varnish wastes, scales from mechanical cleaning of ship hulls, wastes polluted by oil-bearing compounds and fishing industry waste of high salinity should be considered as hazardous.

The surrounding of the tip is cropland. These are lixiviate brown soils belonging to the good rye-complexes. The terrain slopes to NE. Rain waters flow through drainage ditches into a river. Arround the yard up to a depth of 1 meter occur sands of various grain-size distribution and clayey sands; below this thin layer occur clays and clayey sands with interbeddings of dusty clays and silts. Groundwater occur as interbeddings inside the clay layers, as tense water level or as very shallow free level waters inside the sandy-gravel deposits of depressions of the sandy clays roof. The real aquiferous layer one can find at a depth of some 40 meters below the surface.

The operation procedures at the yard do not follow those prescribed for sanitary landfills. The different kinds of wastes delivered are not storaged acc. to their physical and chemical properties but mixed together. No covering layer with inert soil is practiced, though the tip is a source of dust. The heap is now 3m high over the surface. There is no outflow of leachates which fill the bottom of the tip and infiltrate in part to the ground. The composition of these leachates is shown in Table 1; data of leachates from refuse landfills are attached for comparison.

Table 1: Composition of leachates

Parameter	Unit	Case study 1	Case study 2	Leachates from refuse
pH		7.26-7.28	3.05-5.9	7.30-7.85
Alkalinity	meq/L	133-160		84-122
Hardness	meq/L	90-140		78-122
Conductiv.	S/m	8.8-10.3		0.93-1.25
TDS	g/m3	116-124		693-866
COD	gO2/m3	3.5-11.8		0.98-2.49
Chlorides	g/m3	50-61.7	0.24-1.38	1.34-2.63
Sulphates	ppm	155-265	658-1600	32-105
Phenol	ppm	0.34-2.0	-	0.04-1.20
Na	ppm	36.0-51.0		0.85-2.65
Zn	ppm	2.2-4.3	0.02-3.20	0.90-5.2
Hg	ppm	0.5-1.3	0.03-0.19	0.03-2.0
Pb	ppm	0.2-1.3	0.10-0.34	0.10-2.0
Ni	ppm	0.2-2.9	0.21-0.84	0.06-1.6
Cd	ppm	0.07-0.22	0.01-0.09	0.0 -0.1
Cr	ppm	0.01-0.16	1.52-4.84	0.0 -0.11

Table 2: Surface and groundwater characteristics

Parameter	Unit	Pond	Drainage ditch	Piezo-meters
pH		7.7-8.3	6.9-7.6	7.1-7.2
Alkalinity	meq/L	2.7-4.0	4.4-4.8	1.0-1.6
Hardness	meq/L	9.2-10.6	16.5-17.8	14.7-20.8
Conductivity	mS/m	48-52	56-62	65-75
TDS	ppm	332-447	485-692	402-811
COD	ppm	55-98	37-68	11-28
Chlorides	ppm	50-78	55-150	65-75
Sulphates	ppm	31-35	65-72	55-72
Phenol	ppm	0.04-0.42	0.0-0.02	0.0-0.001
Na	ppm	40-50	20-35	17-18
Zn	ppm	0.32-0.65	0.8-1.60	0.41-1.05
Hg	ppm	0.15-0.17	0.14-0.65	0.18-0.63
Pb	ppm	0.08-0.14	0.01-0.05	0.01-0.17
Ni	ppm	0.28-0.42	0.02-0.34	0.02-0.34
Cd	ppm	0.01-0.09	0.01-0.02	0.01-0.02
Cr	ppm	0.04-0.10	0.02-0.09	0.00-0.01

For determination the impact of the wastes storaged upon the soil and water environment, the following elements have been studied:

(1) Waters from a pond, from the drainage ditch as well as from the piezometers situated on the run-off direction and at a distance of some 300 meters from the yard. Results are listed in Table No.2.

(2) Chemical properties of soils arround the yard. Soil samples were removed directly from the surface (0.0-0.3m); the first one in each case in a 3m distance from the yard basis. The distance between the sampling points was 50m. The soil samples have been extracted with water (0.1kg/0.3L) and the following parameters determined: conductivity, chlorides, sulphates. Figure 1 shows the plan of sampling and soil salinity. Table 3 shows the chemical characteristics of the soils arround the stockyard.

(3) Plants especially growing arround the landfill. These were: oat (Avena sativa L.) and pea (Pisum sativum L.). Terms of plants harvesting: overground parts in June, pods of pea in the phase of milk maturity, oat some days after coming to ear. The main elements in plants are in Table 4.

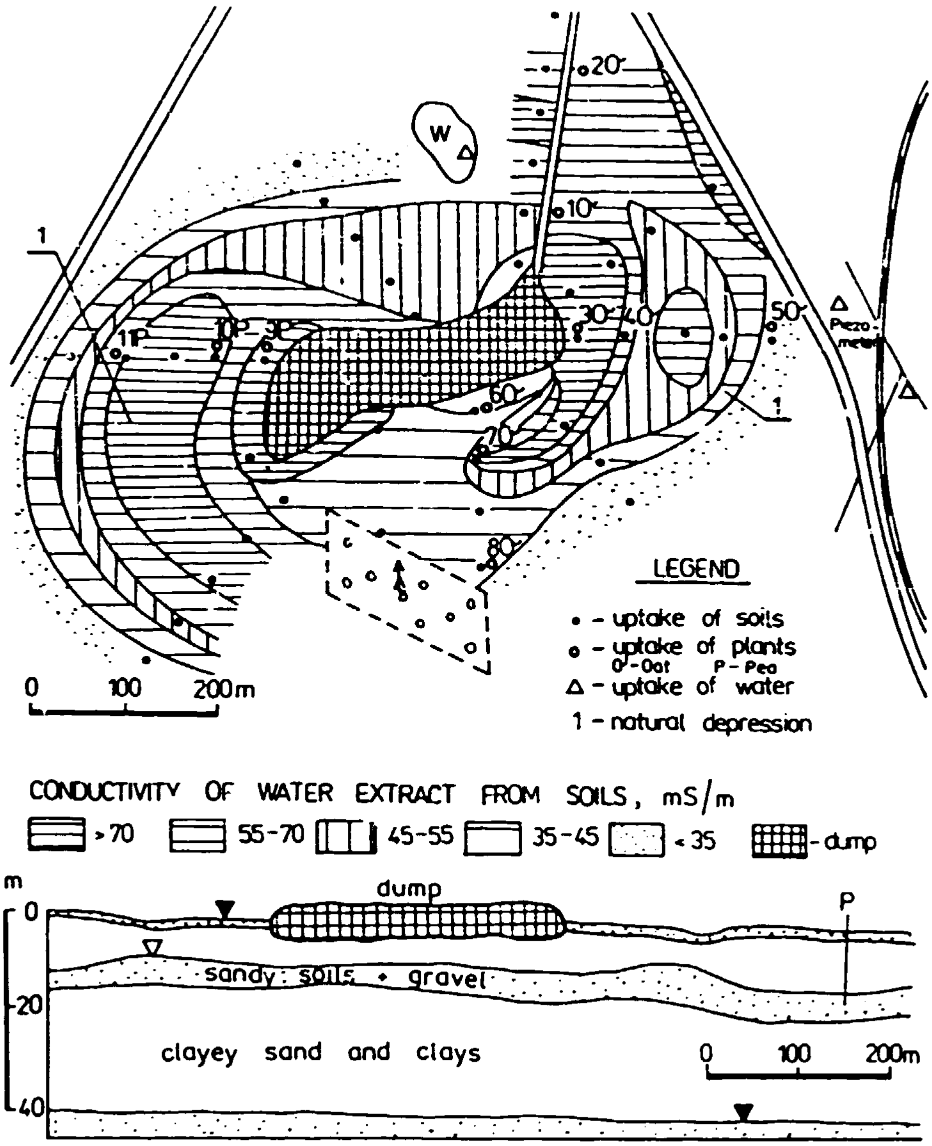


Fig. 1. Salinity of soil around the dump & soil profile.

The second stockyard

The second case study includes a landfill located in a worked out gravel heading with some 20,000 tonnes of wastes tipped of per year wherein 92.4% of precipitation sludges come from a chromium tannery (wastewater treated with $FeSO_4$). The composition of the chrome tanning sludge is as follows: dry matter content 69.9-83.3%, organic matter 50.2-63.5% d.wt., TKN 3.3-4.2% d.wt., Phosphorus 0.13-0.28% d.wt., oil & grease (as ether

extract) 12.1-14.9% d.wt., K 0.03-0.22% d.wt., Fe 7.71-7.8 % d.wt., total Cr 2.4-4.0 d.wt.
The rest of the solid wastes are those from the

Table 3: Soil characteristics

Parameter	Unit	Direction N		S		E		W	
		Distance, m							
		3	300	3	150	3	200	3	200
pH (water)		7.7	6.4	5.2	5.0	6.7	5.1	5.3	4.4
TKN	ppm	672	952	840	620	672	672	784	728
P	ppm	272	309	409	240	227	270	490	360
K	ppm	682	930	930	380	980	320	1100	330
Na	ppm	150	135	190	87	120	81	140	41
Mn	ppm	218	240	97	12	190	55	210	170
Zn	ppm	25	47	18	12	23	17	13	25
Hg	ppm	7.4	17	13	7.2	14	5.8	12	7.4
Pb	ppm	30	14	21	16	24	6.2	38	15
Ni	ppm	24	8.8	12	17	13	4.7	22	2.7
Cd	ppm	2.0	0.9	0.7	0.1	0.8	0.4	2.0	0.3
Co	ppm	1.1	0.8	1.2	1.0	0.7	0.1	2.2	1.6

Table 4: Chemical components of the plants

Plant Sample*)	Total forms, % d.wt. N	P	K	Na	Microelements, ppm Mn	Zn	Cu	Ni	Cd
10 N 50	0.67	0.29	1.8	0.150	123	16	15	1.2	0.65
20 N 150	0.78	0.27	2.4	0.022	127	25	14	2.8	0.08
30 E 3	1.40	0.47	5.1	0.154	654	39	22	3.2	1.02
40 E 50	1.68	0.38	5.1	0.046	208	31	28	1.1	0.17
50 E 200	2.50	0.58	3.4	0.030	227	31	37	0.6	0.04
60 S 3	1.46	0.33	4.8	0.130	349	43	15	24.6	4.36
70 S 50	1.82	0.31	4.3	0.048	298	28	16	6.8	3.45
80 S 150	2.42	0.29	3.6	0.038	181	28	20	4.0	0.06
9P W 3	2.02	0.13	4.4	0.080	180	68	21	11.8	3.02
10P W 50	2.32	0.22	3.4	0.065	133	44	17	2.2	2.61
11P W 200	2.91	0.39	2.7	0.057	45	41	14	1.4	0.14

*) Consecution of Symbols: Sample No; type of the plant: O - oat, P - pea; direction and distance from the landfill in meters.

finishing process of skins and hides. Leachates composition the Reader can find in column 4, of table 1. At the SE side of this tip there is arable land, from the other sides the tip is surrounded by forest. The slope of the terrain is from SE to NW.

At the location of the landfill up to a depth of 0.5-1.5m occur dusty humus, aggredate muds and clay. Below this layer are present sands, gravels, sand-gravel mix, with no numerous pockets of silts and clays. The groundwater level is 1.5-2.6m below the surface. High water levels in the Bober-river are above the bottom level of the landfill. The direction of the groundwater flow is identical with the slope of the terrain.

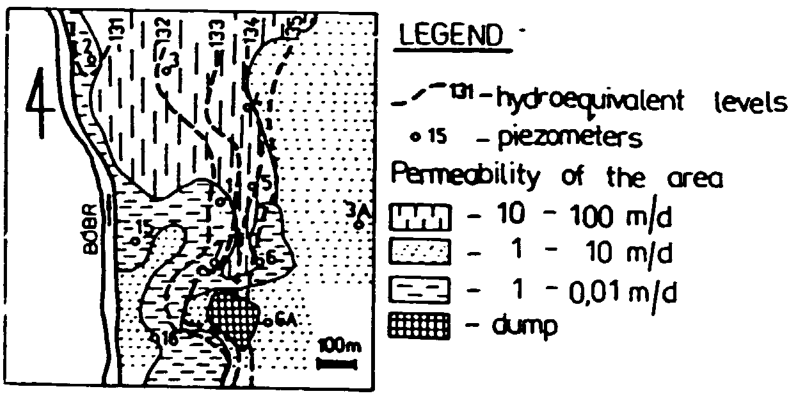


Fig. 2 Hydrogeological structure of the area.

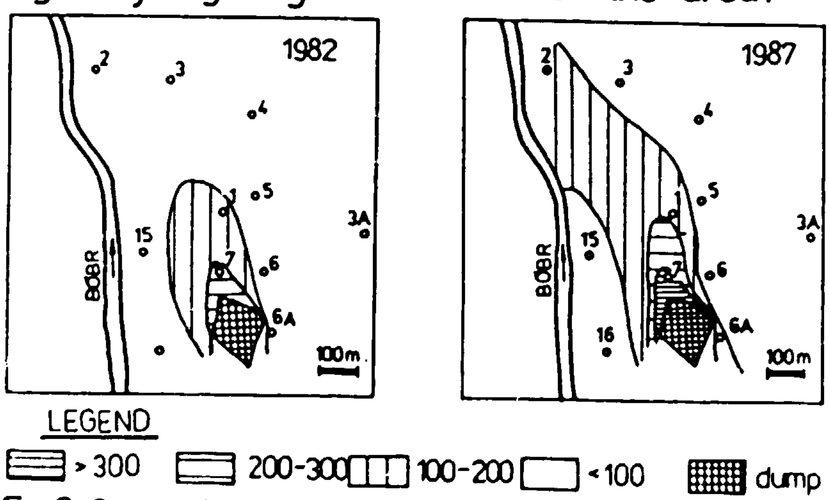


Fig.3 Concentration of sulphates in groundwater, mg/dm^3

Starting in 1978, the quality of groundwater arround the tip has been analysed systematically. The hydro-geological conditions are shown on Fig.2. On Figs. 3 & 4 concentrations of chromium and sulphates as well as their expansion in years (i.e. after 5 and 10 years of operation) are shown as examples only.

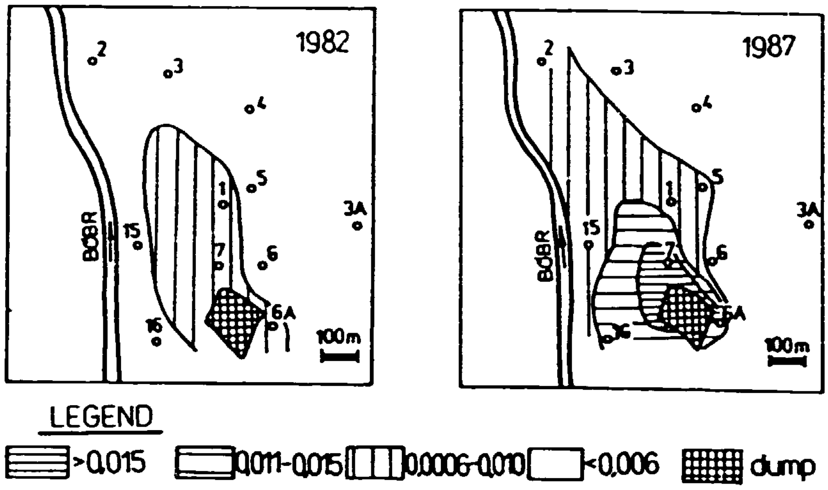


Fig.4 Concentration of chromium in groundwater, mg/dm^3

SUMMARY

A distinct impact of the first landfill on chemical properties of soils can be observed at a distance of no more than 300m from the yard's body. It is manifested particularly by higher salinity as well as by high chlorides and sulphates concentration. Increased concentrations of heavy metals have been observed in a zone varying from 30 to 50 meters only and directly adjoining to the yard. Plants growing there show higher concentrations of cadmium, nickel, manganese and sodium, and lower concentration of nitrogen which gives, in effect, yields of some 30% lower.
The lack of an insulacion layer between the stocked wastes and the groundwater (Case No.2) brings about that we note a distinct impact of wastes upon the chemical composition of the groundwater. During the passed years of the tip's operation, one could observe the increase in groundwater pollution as well as an increase of the contaminated area. Although this case study gave - in terms of environment pollution - objectionable results, it gave, from the other hand, the backgrounds for forecasting of the range of pollution in the coming years.