OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

RESTRICTED

16957

DP/ID/SER.A/1049
16 August 1988
ORIGINAL: ENGLISH

POLLUTION CONTROL RESEARCH INSTITUTE, HARDWAR

DP/IND/83/008

INDIA

Technical report: Pollution Control in Boilers*

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 J.G. Wain
expert in pollution control in boilers

Backstopping officer: S. Maltezou, Chemical Industries Branch

United Nations Industrial Development Organization
Viennna

---

* This document has not been edited.

V.88-27641

ABSTRACT

This one-month assignment was the second part of a split-mission to the Pollution Control Research Institute, Hardwar, to guide the national staff involved with consultancy work and in-house research programmes on the control of air/water pollution with respect to thermal power stations and other topics. At the request of PCRI the scope of the assignment was extended to providing a series of lectures to trainee staff covering environmental impact assessment, air pollution dispersion, boiler water treatment, cooling water circuit conditioning and water pollution topics. Meetings were held with staff of the air pollution group, technical laboratory and water pollution group to discuss current projects and problems.

CONTENTS

RECOMMENDATIONS

1. The Expert is anxious that the views expressed in the last report (Recommendation No 3, 1987) in which research and development programmes were mentioned, should be implemented without delay. The water pollution and air pollution laboratories should be furnished with benches, services etc and the proposed list of 'consummables' (annex 3) purchased.

2. UNIDO to facilitate the implementation of the outstanding commissioning/training programmes required for equipment supplies, in particular the Hewlett Packard Gas Chromatograph and H.P.L.C.

3. That UNIDO give favourable consideration to the award of fellowships to fou nominated members of PCRI. It is proposed that the Fellowship should be of about two months' duration and should be aimed at providing training in applied research experimentation, a study of laboratory design and to include a visit to Hewlett Packard (UK) to obtain training on the equipment mentioned in recommendation No 2. The proposed programme is given in annex 9.

4. As the library is acquiring an increasing amount of technical information, it is suggested that technical staff should be detailed to catalogue the papers, reports etc. As a first step papers etc should be stored in rigid box files (fitted with spring clips) to facilitate easy reference.

5. It is clear that there is a need to ensure that the technical aspects of purchase orders cover all the requirements of PCRI. Orders should include the following:

1. Climatic conditions, giving maximum temperature etc.
2. Purchase through local manufacturers/agents to ensure adequate after sales services, whenever possible.
3. Provision of spares for two years' operation, under conditions prevailing at PCRI.
4. Provision of training manuals written in English.
5. All equipment labels to be written in English.
6. Price to include installation and commissioning at PCRI.
7. PCRI staff to receive training at suppliers' factory.
8. Purchase order to include performance guarantee.

6. It is suggested that Departmental Managers should produce time sheets, on a weekly basis, showing the time spent by staff on projects in hand. This information could then be used to provide a more accurate assessment of costs.

7. At the request of PCRI, a list of possible research investigations has been prepared as follows:

(a) Evaluation of Chemical/Biological methods of treatment of producer gas plant effluent (results required by BHEL, October 1988).

(b) Evaluation of dust suppression techniques available for use in crushing plants etc.

(c) Evaluation of polyelectrolytes in the treatment of overflow from ash-slurry ponds.

(d) Study of the anaerobic digestion of molasses and distillery wastes to establish optimim process operating conditions with maximum methane gas production (together with the necessary treatment for the waste from the digester).

(e) The laboratory scale units described in annex 4 should be assembled by the PCRI staff so that the biological oxidation of producer gas effluent can be studied alongside the chemical methods of treatment proposed by Dr Mayer.

(f) That the technicians in the Air Pollution Laboratory should receive training in instrumentation maintenance, fault-finding techniques and instrument repairs. This tuition to be obtained either from BHEL or Roorkee Polytechnic on a part-time release basis.

INTRODUCTION

The original job specification limited the assignment to studying the water and air pollution control problems associated with steam boilers (See annex 11).

As with the previous assignment the Expert was requested to become involved with current projects and problems. In addition lectures were given to a group of trainee engineers who had recently joined BHEL and had been assigned to PCRI. The topics discussed were as follows:

1. Air Pollution Group
   (a) Visit to Impregnation Plant, BHEL
   (b) Visit to Dehra Dun and the Dun Valley in connecting with ambient air pollution caused by crushing operations, cement works' emissions, lime kiln operations.
   (c) Discussion with laboratory staff.

2. Technical Laboratory Group
   (a) Discussion with laboratory staff on:
      (i) Trace metals in fly ash
      (ii) Size Particle - size analysis
      (iii) Determination of sulphates - Barium Chloranilate method
   (b) Commissioning of Adiabatic Bomb Calorimeter
   (c) Acquisition of surface active agents and polyelectrolytes for floccitation studies

3. Water Pollution Group
   (a) PCRI had received a request from BHEL for assistance with the pollution control requirements needed for a power station under construction at Koppa Kheda, Nagpur.
   (b) A visit was made to BHEL Thermal Power Station, Hardwar to discuss impending modifications.
   (c) The anaerobic digestion of molasses/distillery wastes was discussed and laboratory scale equipment designs prepared.

4. Training

A series of lectures were given to seven engineering trainees who had been allocated to PCRI by BHEL, for their training period. As these engineers had had no previous experience of industrial pollution control processes, the lectures were arranged so as to make the trainees aware of the wide range of topics involved with the control of pollution.

ADMINISTRATIVE MATTERS

On arrival at PCRI I met Mr Gupta who informed me the Professor Mahajan was to return to I.I.T. Bombay and had left PCRI the previous day. Mr Gupta had been appointed Acting Head pending the announcement of a new appointment.

I mentioned that I had met Mr M Gupta and Dr J Giesler, of the WHO Regional Office, Delhi and that they had experessed interest in the forthcoming PCRI workshop to be held in Delhi in November 1988. Mr Gupta agreed to supply them with information. I agreed to supply a paper for the workshop.

At a meeting with Mr Gupta and Dr A Mayer, I agreed to work closely to avoid overlap; Dr Mayer concentrating on engineering aspects and chemical methods of treatment.

Time Accounting Procedure

Suggested that Mr Gupta might like to consider instituting a system whereby Managers would submit (on a weekly basis) an account of the time spent by their staff on the various projects in hand. The purpose of allotting time in this way is to obtain accurate information for costing projeccts.

Appointment of Mr S B C Agarwal, Head PCRI

On April 15 I was introduced to Mr S B C Agarwal, on his appointment as Head PCRI. Mr Agarwal is an electrical engineer with experience of design work and marketing. He has been at Hardwar since 1963 and in view of his being a senior deputy general manager had been made answerable to the Executive Director. The opportunity was taken to raise the following points:

(a) I reiterated the recommendation for someone experienced in marketing/ project cost estimating and Mr Agarwal expressed his agreement.

(b) I spoke of the need for the purchase of small 'nuts and bolts' items to enable investigation work to be carried out on the lab scale.

(c) Suggested the problem of dust in laboratories could be alleviated to some extent by placing a thickness of gravel around the laboratories.

R & D Project Proposals

At the request of Mr Gupta comments were made on five proposals which were presently under consideration for funding. The following points were made:

General
- all projects should be reviewed to ensure there is no duplication of capital equipment, especially checking the orders presently with UNIDO
- actual prices of equipment should be obtained.

Development of plot scale anaerobic digesters
- Before proceeding to the acquisition of a mobile pilot plant it is suggested that laboratory investigations are carried out studying both fluidised bed and fixed film processes.

Pilot Unit for Waste Water Treatment using Bentonite
- This project should first be evaluated on the laboratory scale before proceeding to a pilot plant unit.

Small Size Incinerator for Solid Wastes/Sludges
- It is suggested that this project should be limited to the study of small batch-type (intermittent operation) incinerators as used in those industries where waste arises on an irregular basis. The study should include a literature survey, acquisition of information on batch incinerators presently available in India, and from the information collected, the selection of a unit for evaluation and, if necessary, modification to suit local conditions.

Limnological Studies of Industrial Effluents - This work is intended to identify indicator organisations for establishing the presence of industrial pollution. The estimated cost is somewhat high for the time quoted for the length of the project. Perhaps it would be advisable to hire a boat/boatman rather than PCRI purchasing its own and also to check the price of the micro manipulator.

Development of High Volume Sampler/Stack Sampler - The development, design and assembly of this type of equipment seems to be within the capability of PCRI. It is understood that the equipment will be capable of being operated for 24 hours and it is the intention that one or more of these instruments will be available by the time of the workshop.

Requests for Assistance - During the course of the assignment many requests were made for additional information. To acquire this information will require time to locate the source, prepare correspondence and make visits (where necessary). A list of the requests received are given in Annex 8 together with an estimate of the time likely to be spent in the collection of this data.

UNIDO Fellowships - The following outline proposal is submitted to provide the four participants with experience of applied research experimental work covering topics about to be studied by PCRI, selected industrial experience eg Leather Research Association, Thermal Power Stations etc; and environmental impact assessment. The length of duration will be about 2 months. Further details are given in Annex 9, together with an estimate of the time necessary to make arrangements with participating organisations. Also to include training at Hewlett Packard factory.

TECHNICAL MATTERS

It was agreed that the Expert should present a series of lectures to the trainee-group with the intention of making them aware of the scope of work likely to be encountered in pollution control and environmental impact assessment. In addition, meetings were held with the various departments of PCRI to discuss current projects and problems. The following paragraphs describe the projects under investigation together with possible solutions.

1. AIR POLLUTION GROUP

(i) BHEL Impregnation Plant - This project had been requested because of workers' complaints about the fumes which are released when the pressurised impregnation tank is opened to remove the impregnated copper bars. We were informed by management that the working arrangement is the same as that carried out by the licensor at its factory in Germany. The main difference would be the ambient temperature which, on the morning of our visit, was 35°C.
On opening the impregnation tank there was a slight odour which could possibly have been plasticizer (diethylphthalate) present in the epoxy resin formulation.

Proposed solution - the two operators issued with paper masks should be issued with nose and mouth masks filled with an activated carbon filter. The number of fans in the roof should be increased to provide improved ventilation. The Expert agreed to obtain the manufacturers' recommendations for use of LEKUTHERM X18 LEKUTHERM HARDENER M and their toxicity data together with that of the plasticizer used.

During the course of the visit to the impregnation plant it was noted that organic vapours were present in the finishing/testing shop (adjacent to the impregnation unit). These were released when the bars were coated with conducting varnish (they included xylene, with butanol/methyl ethyl ketone present in the thinners).

Proposed solution - the parties be issued with nose/mouth masks fitted with activated carbon filters and the ventilation in this area improved. The Expert agreed to contact the varnish manufacturer for recommended methods of use and toxicological data.

(ii) Doon Valley project - This project was initiated by Dr Indira Kouli, Convenor of the Dehra-Dun Chapter of Intach, an influential environmental group interested in improving the environment of the Doon Valley. The main emissions of present concern were:-

(a) vehicular traffic in the centre of Dehra Dun.

(b) Dust generated by rock crushing operations.

(c) Gaseous emissions from a large number of small scale lime kilns situated adjacent to residential areas.

(d) Emissions produced by a factory manufacturing calcium carbide.

(e) Odours produced by a distillery utilising molasses.

(f) Particulate matter emitted by a vertical shaft cement kiln.

The purpose of the visit was to select sampling sites at the places indicated by the client. Contact was made with the Office of the District Magistrate and the Regional Office of the Uttar Pradesh Pollution Control Board. As two of the sampling points (one in the centre of Dehra Dun, and the other on the roof of a dairy adjacent to the lime kilns) were already being monitored by the U.P. Polution Control Board it was considered useful to use the same sites, so that results could be compared.

During the course of the discussions with Dr Kouli it was appreciated that industrial development in the valley must continue but that full consideration should be given to keeping adverse impacts on the environment to a minimum. In addition it was recognised that small scale industries would not be able to afford expensive methods of pollution control. The Expert was able to mention a few simple techniques which could be applied to crushing plants and these are given in Annex 7. Probably the worst situation is the emissions from the lime kilns because of their close proximity to residential areas. It is likely that some form of incentive will be required to move these lime kilns away from the town, closer to their raw material supplies. It is for consideration whether an industrial estate could be established to house them or whether the kiln owners could be persuaded to join together to operate a modern lime kiln, complete with appropriate dust arresting equipment.

Meeting with Laboratory Staff - From discussions held with the laboratory staff the following points emerged:-

(a) Operation of the Casella dew-point apparatus involved the use of a calculator disc to determine the dew point temperature. The operating instructions were not too clear and assistance was requested. After examination of the calculator and studying the operating manual it was possible to demonstrate the correct procedure for using the calculator.

(b) During discussions with the laboratory technicians, during which it became apparent that there was both a need and an interest in some training in instrument maintenance, fault-finding techniques, and instrument repairs. I agreed to recommend that some training be initiated by PCRI.

2. TECHNICAL LABORATORY GROUP

Several meetings were held during the course of the assignment and the main topics discussed were as follows:-

(i) Acquisition of Polyelectrolyles/Surface Active Agents - It was suggested that PCRI should acquire samples of a range of poly-electrolyles (anionic cationic and non-ionic including starch, types) so that they would be readily available for investigation work on the settlement of suspended solids. A similar range of surface active agents would also be useful for dust suppression evaluations etc. Manufacturers have, in the past, been known to supply samples (50g - 100 g) free of charge for experimental purposes.

(ii) BHEL THERMAL POWER STATION - A visit was arranged, at the request of BHEL, to discuss forthcoming modifications which were to be made to the power station. Mr. J.D. Goel, the Manager, explained that in about six months' time the power station was to be converted to oil-burning and as a result the production of fly ash would cease. This meant that an alternative method of disposal would be required for the effluent from the producer gas plant (presently mixed with fly ash slurry to absorb phenols). The amount of producer gas plant waste was $10m^3/h$ (on a continuous basis) with a monohydric phenol content in the range of 75-125 mg/l.

It was agreed that this problem was suitable for laboratory scale investigation. Dr Mayer provided several chemical methods of treatment which could be evaluated and biological treatment (using both activated sludge and rotating-disc systems) was also possible. Suitably sized laboratory scale units were designed and these are given in Annex 4.

In addition to the above mentioned modification Mr Goel also explained that the existing turbines were to be replaced by a combined cycle turbine which was being supplied by BHEL R & D. As this is a somewhat new development a description of the operation of this type of power generation unit is given in Annex 4a, together with recommendations for boiler/cooling water conditioning. It was suggested that PCRI should contact BHEL R & D to obtain full details of this new system. It will be necessary to know whether there will be an increased noise level (from air compressor(s) and what will be the state of the flue gas emissions (exit temperature, gas velocity, sulphur dioxide content etc) since the oil may contain more sulphur than the coal.

(iii) Adiabatic Bomb Calorimeter - During an examination of equipment supplied by UNIDO it was noted that the bomb calorimeter had not be commissioned. On inspection it was found that the Beckmann thermometer had a 'star' crack in the mercury bulb reservoir so it was decided to proceed using the electronic temperature measuring unit alone. Initial attempts to stabilise the temperature of the system were unsuccessful because of the ambient temperature of the laboratory (note laboratory temperature +30°C, water temperature 30°C). The equipment was transferred to an air conditioned room, but further difficulties were observed with the operation of the water cooling unit. It appeared that the heat generated by the compressor could not be dissipated adequately (ambient temperature 28°C) and this caused a slow rise in cooling water temperature. The rise in temperature was arrested by adding ice to the cooling system periodically. It was possible to demonstrate the determination of calorific value using benzoic acid (making an adjustment to the temperature rise for the rise caused by the high ambient temperature). It will be necessary to check the temperature rise measured by the electronic unit with that obtained with a Beckmann Thermometer when this is available. The expert agreed to contact the manufacturer of the water cooling unit to see if it could be modified for use at higher ambient temperature.

3. Water Pollution Group

The main points discussed with this group were as follows:

(i) Koppa Kheda Power Station - This is a 2 x 220 MW coat-fired station presently under construction near Nagpur. PCRI had been requested by BHEL to advise on the water pollution control required to meet the pollution boards discharge conditions. These were:

Suspended solids	not more than	30 mg/L
Oil/grease	not more than	10 mg/L
B.O.D.	not more than	20 mg/L
pH		6.5 - 8.5

The river is used as a potable water supply downstream of the power station.

The main sources of effluents were given as:

Ash pond overflow
Boiler Blowdown
Demineralisation plant wastes
Cooling water circuit blowdown
Oil storage and unloading area.

Suggested methods of treatment are given in Annex 10.

(ii) Producer Gas Plant wastes - This project seemed to be a very useful one for PCRI because it will be possible to oversee the transfer from the laboratory scale investigation to the plant scale as this is nearby and will not require large scale fabrication work. The design of the laboratory u: .s is given in Annex 4, with the equipment list given in Annex 3.

(iii) Anaerobic Digestion of Molasses wastes - This project should also be evaluated on the laboratory scale before proceeding to designing a mobile pilot plant for use at factory sites. In the case of distillery wastes it will be necessary to control the ph (they tend to be slightly acid) to encourage the growth of methane-producing bacteria rather than the carbon dioxide forming organisms. PCRI have considerable literature on this subject but a line diagram and equipment requirements are given in Annexes 3 and 4.

TRAINING

Each BHEL recruit 200 graduate engineers for training in various departments. PCRI were allocated seven (civil, electrical, mechanical) trainees and Experts were requested to provide lectures. As Dr Mayer had already commenced his lecture programme and was intending to concentrate on engineering aspects and chemical treatment of wastes, it was agreed that I should cover chemical analysis and the industrial treatment of water in the first instance. The following is a summary of the lectures given:

(a) Chemical aspects of B.O.D., C.O.D., T.O.C. pH

(b) Hardness, Langelier Index, free carbon dioxide.

(c) Preparation of technical specifications for purchase enquiries and purchase orders and evaluation of quotations.

(d) Chemical processes involved in the treatment of water for use in boilers, boiler water conditioning and the chemical conditioning of the cooling water circuit.

(e) Silica in boiler waters and steam.

(f) Environmental Audit procedures.

(g) Industrial processes for the control of gaseous emissions, liquid wastes, solid wastes disposal, factory atmospheres and plant safety.

(h) Performance characteristics of industrial pollution control processes.

(i) Environmental Impact Assessment.

(j) Airborne emissions - plume rise, effective chimney height.

(k) Water pollution control - design parameters for a conventional sewage treatment plant and electro-chemial methods of treatment.

At the request of the Training Co-ordinator a questionnaire (45 short questions) was prepared to obtain some 'feed-back'. At the final meeting trainees were asked to check through their papers and each question was discussed in turn. All trainees showed that they had understood most of the information provided, though one or two gave the impression they were not interested in pollution control work.

ACKNOWLEDGEMENTS

The author wishes to record his thanks to the Director, Deputy Director and staff members for the assistance given to him during his stay at PCRI. He is pleased to note that the good working relationships established during the first visit have continued and looks forward to further association with the work of PCRI.

ANNEX 1

TIMETABLE OFF MISSION

5 April 1988	Departed Coulsdon, UK	0730 hr
6 April 1988	Arrived New Delhi, Claridges Hotel	0300 hr
6 April 1988	Attended UNDP for briefing	1300/1400 hr
6 April 1988	Visited WHO Regional Office Shriram Food & Fertilizer Co	1400/1700 hr
7 April 1988	Departed for PCRI, Hardwar Arrived PCRI Met Mr Gupta who informed me of Professor S P Mahajan's return to ICT, Bombay.	0930 hr 1400 hr
8 April 1988	Had discussions with Dr Mayer and senior staff to determine work programme. Was requested to prepare course of lectures for new group of trainees. Agreed to work closely with Dr Mayer to avoid overlap.	
9 April 1988	Met Mr Meheshswari to discuss current interests including methods of dealing with power station discharges. Mr Islam, SIDFA, UNIDO who visited PCRI pm. Visited BHEL plant to discuss problems in: (i) metal plating department (ii) producer gas plant effluent (iii) fly ash disposal	
11 April 1988	At request of Mr Gupta examined proposals for five projects submitted to BHEL for funding and made comments. Lectured on chemical aspects of B.O.D., C.O.D., TOC, pH, Hardness. Had discussions with Dr Trehen.	

12 April 1988 — Discussion with Dr Trehen on projects. Lectured on purchasing procedures. Provided Dr Mrs Shrivastava with methods of analysis of agricultural chemicals. Left for Mussouri.

14 April 1988 — Had discussions with Mr Gupta on administrative matters. Returned to PCRI from Mussouri.

15 April 1988 — Had discussions with Dr Trehen and Mr Sambhia. Lectured on the preparation of technical specification for the purpose of equipment. Commenced discussion on the chemical processes involved with the conditioning of boiler waters. Was introduced to the new head of PCRI.

16 April 1988 — Lectured on chemical aspects of water conditioning for TPS cooling water circuit. Commenced discussion on Environmental Audit. Visited TPS, BHEL to have discussions with Mr J D Goel, Manager.

18 April 1988 — Discussed distribution of trace metals during the combustion of coal in TPS, with Dr Ramini. Produced equipment list for materials required for lab scale investigations. Designed suitably sized aeration unit, and rotating disc contactor. Discussed particle-size analysis with Dr Ramini and Dr Shrivastava.

19 April 1988 — Had meeting with Dr Mayer, Dr Trehen and Mr Meheshsari to discuss ways and means of dealing with the problems raised by Mr Goel, Manager BHEL, TPS and at the TPS Koppa Kheda.
Lectured on precautions required with the presence of silica in boilers and steam. Continued discussion of procedures for environmental audit and commenced discussion of industrial processes used for controlling gaseous emissions, liquid wastes, solid wastes disposal, control of factory atmospheres and plant safety.

20 April 1988	Further discussions with Dr Mayer, Dr Trehen, Mr Meheshswari on the PCRI project for the Koppa Kheda Power Station. Lectured on performance characteristics of industrial control process. Introduced E.I.A.
21 April 1988	Discussion with Mr Meheshswari on the design of laboratory scale equipment and equipment lists. Lectured on E.I.A. covering hydrological, landscape, ecological, employment, transport, airborne emissions commenced commissioning of adiabatic bomb calorimeter.
22 April 1988	Lectured on airborne emissions, including calculations on plume rise, chimney height and effective height. Discussion with Mr Meheshswari on possible methods of dealing with effluent from fly ash ponds.
23 April 1988	Further discussion with Mr Meheshswari on fly ash disposal - including estimation of evaporation rates. Lectured on flue gas composition, plume/effective height calculations.
25 April 1988	Had discussion with Dr Shrivastava on analysis required on sewage samples. Gave lecture on water pollution and design parameters for conventional sewage plant and electrochemical methods of treatment. Had further discussion with Mr Meheshswari on the Koppa Kheda project.
26 April 1988	Visited epoxy impregnation plant to observe method of working and to note extent of emission of toxic fumes. Continued commissioning of adiabatic bomb calorimeter.
27 April 1988	Met staff of the technical laboratory to discuss standard methods of analysis. Continued commissioning of bomb calorimeter.

30 April 1988	Had discussions with technicians in the Air Pollution Department. Met Mr Meheshswari for further discussion on the Koppa Khedda project. Met trainees to mark papers and discuss answers.	
2 May 1988	Had meeting with Mr Agarwal and Mr Gupta to report on all aspects of the mission.	
3 May 1988	Departed BHEL for UNDP, Delhi.	0645 hr
	Arrived UNDP, Delhi. Had de-briefing discussions with Mr Md Islam and Mr Sat Pal.	1115 hr
4 May 1988	Departed Delhi for Vienna via Frankfurt.	0500 hr
	Arrived Vienna.	1430 hr
5 May 1988	De-briefing.	
	Departed Vienna for London.	1945 hr
	Arrived Coulsdon.	2315 hr

ANNEX 2

LIST OF BOOKS ETC PROVIDED

1. Samping and initial preparation of sewage and waterworks sludges, soils, sediments, plant materials and contaminated wildlife prior to analysis.

2. The analysis of agricultural materials.

3. Guide to safe practices in chemical laboratories.

4. Waste Management Paper No 17 - wastes from Tanning Leather Dressing - Fellmongering.

5. Waste Management Paper No 11 - Metal Finishing Wastes.

6. Analysis of Water, second edition - General Principles and Techniques.

7. Trace metals from the coal combustion emissions.

8. Air Pollution Injury to Vegetation.

9. Environmental Effect of utilising more coal - Ed F.A. Robinson.

Papers

Trace metals in soil, B.E. Davies, Chemistry in Britain, February 1988.
Determination of sulphates by Barium Chloramilate Method (with supply of chlor anilic acid).

ANNEX 3

EQUIPMENT REQUIREMENTS FOR LABORATORY SCALE INVESTIGATION OF PRODUCER GAS EFFLUENT AND ANAEROBIC DIGESTION OF MOLASSES WASTE

Acrylic sheet (6 mm) 4 sheets 4' x 4'
Acrylic sheet (2 mm) 2 sheets 4' x 4'
Perspex cement

Flowmeters

Flow Lab-kit Gapmeter (FJD-201-Y) for liquids and gases comprising five metering tubes, wire floats, three fine control valves. Ten ranges for air 60 ml/min - 100 litres/min and six for water 10 ml/min - 4.4 litres/min, with calibration charts all in carrying code.
Accessories FJD-203-5025 Tube/float assembly 5-100 ml/min for air
FJD-203-503Q Flow range 10-250 m/air/min

Pumps

Watson-Marlow (PYH-680) peristaltic, single channel. Variable speed up to 100 rpm for 200-250V 50Hz power.
Tubing - 3 metres silicone rubber 3.2 mm bore 1.6 mm wall
" " " " " 1.6 mm " " "
" " " " " 0.8 mm " " "

Air Compressor

Output 3.25 litres/min free air for use on 220-240V 50Hz single phase. (Gallenkamp PXW-520-S)

Tubing

Flexible - 5 metres - heavy wall - 6.5 mm bore x 5 mm wall TWR-460-150F
Rubber - 5 metres - heavy wall - 10 mm bore x 7 mm wall TWR-460-190D

1 Tube of silicone grease (for preventing build-up of organisms on sides of aeration/settlement tanks).

Glass Tubing, Borosilicate Glass, (Pyrex)

1 pack 6 mm bore (9 lengths x 1.5 m) TWL-530-060V

1 pack 8 mm bore (5 lengths x 1.5 m) TWL-530-080X

1 pack 10 mm bore (6 lengths x 1.5 m) TWL-530-100L

Glass Rod, Borosilicate Glass, (Pyrex)

1 pack 4 mm bore (11 lengths) RND-380-030G

1 pack 7 mm bore (5 lengths) RND-380-150T

1 pack 9 mm bore (3 lengths) RND-380-190H

PVC Tubing

10 metres N6.5, 6.5 mm bore

10 metres N12.5, 12.5 mm bore

Plastic Adapters

- straight form. 2 packs. ADF-330W
- T-shape. 10 items. 2 packs. ADF-360B
- Y-shape. 10 items. 10 mm. ADF-741-030X

1 Blowpipe, Gallenkamp, BYG-500-E for coal gas, natural gas or butane/propane.

Tools - 1 Glass tubing cutter - GTB-580Q

Tool set, comprising triangular reamer, curved edge reamer, forceps etc in plastic case - GTB-300-V

10 Screw clips, Hoffman CNK-440-H

Rubber Stoppers - 2 packs - assorted sizes 9 mm - 23 mm (5 of each) SYH-480-S

25 mm - 5 mm (2 of each) SYH-480-S

1 Set Cork Borers, plated metal, 4 mm - 18 mm - CSD-550-030V (set of 12)

1 cork borer sharpener - CSD-570-Q

5 Gas distribution tubes (domed) - porosity 0 GFD-750-010X

5 " " " " " 1 GFD-750-030Y

5 " " " " " 2 GFD-750-050C

2 Sintered glass thimble (rapid flow) 1 GFD-830-011S

3 Aspirators - 10 litre capacity - ASP-330

2 Aspirators, thick polyethylene, two handles, 20 litres, ASP-620-010N

2 Aspirators, rigid polythene, two handles, 60 litres, ASP-620-070S

2 Stirrers - air driven - and mounting tube, instructions but without rotor - SWR-450-010L

1 Stirrer, variable speed, Citenco, range 0 - 6000 rpm for 220-240V 50Hz supply - SWR-300-010B

2 Ground sleeve glands with screw cap, ST 20/2 Thread 13, cone 19 QSV-620-R

1 Tool Kit, laboratory workshop, comprising: pliers (side cutting), Drills set, drill, (hand brace) files (flat, round) files handles, hammer, centre punch, hacksaw (10 blades), snips, mole wrench, screwdrivers (heavy duty, Phillips No. 2), scissors, measuring tape 2 m, Rule 10, spanner adjustable, knife, duster in suitable metal case with handles TOL-290-Q.

2 Andreason particle size apparatus - graduated 0-20 cm fitted with 29/32 joint with standard 10 ml pipe. PBW-200-W

1 Aztec Sedimentation 6 Jar Tester - comprising timer (0-30 min), 6 x 1 litre sedimentation jars, six variable - WHT-300-010G.
Spares. 6 borosilicate glass test jars.

10 Retort Stands (bases 315 mm x 200 mm) with two M10 threaded holes STA-522-E

10 Retort Stand Rods, bright stainless steel, M10 threaded 1000 x 12 mm STA-860-090G (for above stands).

10 Bossheads, technico - STE-330-101F

10 Clamps, retort stand, technico - STE-300-101D

3 Separating funnels, pear shape, PTFE stop cock 250 ml FPM-630-090Y

3 Separating funnels, pear shape, PTFE stop cock 1000 ml FPM-620-130W

6 funnels, cylindrical, with interchangeable glass stopper, 1000 ml FPM-240-130B

LOCAL AGENT - FINDEX INDIA LTD

ANNEX 4

LAB SCALE EXPERIMENTAL EQUIPMENT

Rotating Biological Contactor

Suggested Requirements -

BASIN - 25 litres

DISC SPEED - 20 rpm, PERIPHERAL SPEED - 60 f/m

DISC SUBMERGENCE - 40%

DISC AREA $35f^2$

Suggested size - IF ROTATION is 20 rpm and PERIPHERAL SPEED IS 60 f/m

then CIRCUMFERENCE OF DISCS = $\frac{60}{20}$ = 3 feet

$\therefore$ D = 3 and D 1 foot. r = 0.5

DISC AREA = $35f^2$

$\therefore$ 1 disc = $(0.5)^2 = 0.7855f^2 \times 2 = 1.57f^2$

$\therefore$ No. of discs required = $\frac{35}{1.57} = \frac{22}{}$ (to nearest whole No)

Size of Basin

Say 1.25f wide (to accommodate diam of disc (1 ft)

DEPTH OF SUBMERGENCE = 5"

So allow sides to be 6"

$\therefore$ length of basin = $1.25 \times 0.5 \times X = 25$ litres = $0.88\ f^3$

$\therefore$ X = 1.4 feet

So BASIN DIMENSIONS = 1.4 feet x 1.25 x 0.5

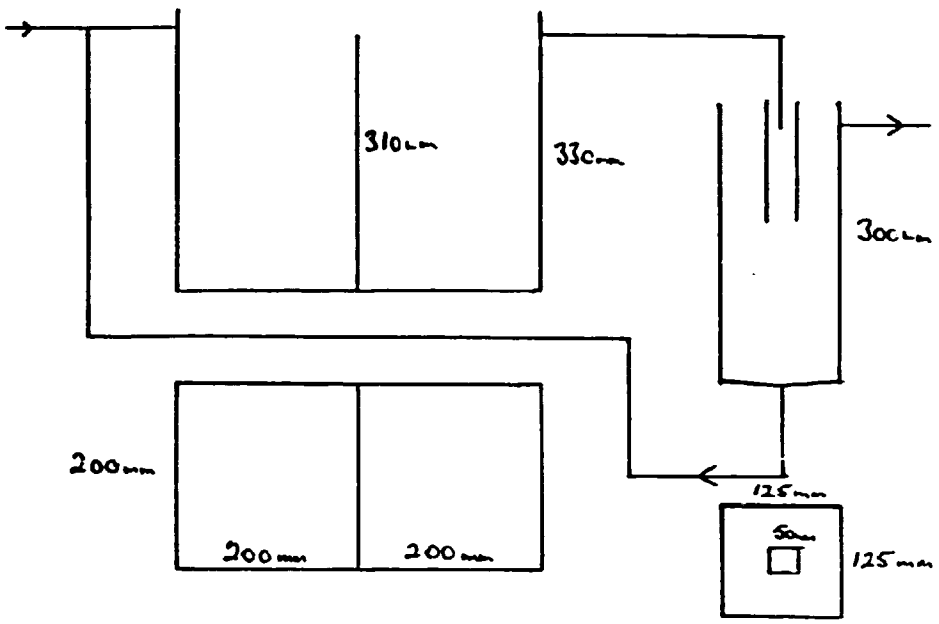
DISCS (22 number) = 1 feet diameter

DEPTH OF IMMERSION = 5 inches.

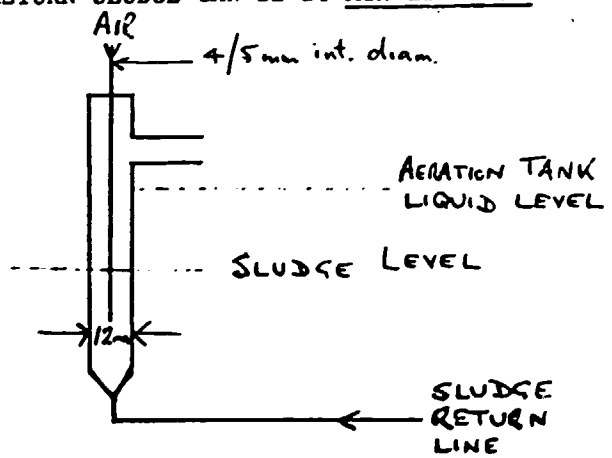
Activated Sludge System

FOR PRODUCER GAS PLANT.

TAKE AERATION TANK CAPACITY TO BE 25 litres AND ARRANGE RECTANGULARLY, WITH PARTITION.



RETURN SLUDGE CAN BE BY AIR LIFT PUMP MADE FROM RIGID TUBING.



FLOW RATE FOR PRODUCER GAS PLANT EFFLUENT GIVEN PHENOL LOADING OF

33 lb/1000f^3/day = 15 Kg/28.4 m^3/day

= 0.528 Kg/m^3/day

ANNEX 5

PRESSURISED FLUIDISED POWER GENERATION SYSTEM

Mr Goel, the Manager of the TPS, stated that a 'combined cycle' power generation unit is to be installed at Hardwar (in place of the existing coal fired TPS) by BHEL R & D.

One of the first high pressure fluidised bed systems was commissioned at BUCRA, Leatherhead in 1969. Following the successful evaluation of this plant an 85 MW (thermal) prototype plant was built at Grimethorpe, Yorkshire, UK in 1979/80 (funded by the International Energy Agency). A further larger demonstration plant was planned (170 MW) for the American Electric Power Company in Ohio.

As Mr J D Goel explained, the new plant will burn oil in a high press chamber in the presence of compressed air. The hot gases will then be expanded through a gas turbine, before injection into a waste heat recovery boiler, operating at 35-48 bars. The temperature of the hot gases was quoted as 550°C and this lower temperature of combustion will minimise the production of oxides of nitrogen.

From experience gained at Grimethorpe (the exit gases were passed through two primary cyclones, two secondary cyclones and a tertiary high efficiency cyclone) the following distribution trace metals in ash occured:

Bed Ash - 25% of trace metals released by combustion retained
Primary Cyclones - 64% of trace metals captured

Concentrations of trace metals leaving tertiary cyclone

Cr - 315 mg/kg Cu - 56 mg/kg, Ni - 202 mg/kg, Zn 265 mg/kg
Cl^- - 48 mg/kg F^- - 2.3 mg/kg

Boiler Water Conditioning/Cooling Water Conditioning

The installation of this new plant should provide a good opportunity for PCRI to advise on the proper conditioning of boiler water and cooling water.

The copy of BS 2486:1978 - Recommendations of Treatment of water for land boilers, left with PCRI in 1987, has all the relevant information e.g. Recommended waterquality for water-tube boiler at 60 bar.

	Feed Water at Economizer Inlet
Total Hardness (as mg/l Ca Co_3)	0.5
pH value	8.5 - 9.5
Oxygen (as mg/l O_2 max)	0.01
Iron + copper + nickel mg/l max	0.02

Boiler Water

$Na_3 PO_4$	20 - 50 mg/l
Caustic Alkalinity mg/l Ca Co_3 min)	60
Total alkalinity (mg/l Ca Co_3 max)	300
Hydrazine (mg/l $N_2 H_4$)	0.05 - 0.3
Dissolved Solids (max)	1200 mg/l
Silica (mg/l Si O_2)	20 (must be less than 0.02 mg/l in steam)

NOTE - If spray attemperation is employed special attention should be paid to the water quality of the spray. Only volatile chemicals should be present (to avoid solid deposition in the superheater). Water should contain not more than 3 mg/l solid matter. If austenitic steel is present solid matter should be less than 0.1 mg/l. In either case the silica content of the spray should be similar to that of the steam (not more than 0.02 mg/l as Si O_2).

Cooling Water Conditioning

It would be worthwhile considering inviting tenders from Specialist Companies dealing with pre-plant cleaning, passivation, and conditioning of cooling water circuit. PCRI have the information to advise including the technical specifications necessary for preparation of enquiry notices and purchase orders.

ANNEX 6

Start-up Procedure for Biological Processes

AEROBIC SYSTEMS

1 Obtain quantity of sewage and sludge from oxidation ponds.

2 Fill aeration tanks and commence aeration.

3 Obtain crude sewage and operate system for few days, adjusting aeration to maintain D.O at not more than 2 mg/l. M.L.S.S. should be about 2 - 4000 mg/l.
Suggested loading is 0.3 Kg B.O.D./Kg MLSS/day.
If crude sewage has B.O.D. of 300mg/l then volume of 83 litres/day is required.

4 Note when effluent is sparkling, clear and sludge is settling readily.
N.B. Retention of sludge in settlement tank for more than 2 - 4 hours could cause anaerobic conditions (observed by sludge rising to surface on bubbles of nitrogen etc.).

5 Continue treatment with crude sewage but add 10% phenolic wastes. Operate for few days at this dilution. If effluent remains OK and phenol removal takes place then increase phenol waste to 20%, 40%, 100% monitoring for removal of phenol, by amino anti pyrine method.

If we assume it is possible to operate at a phenol loading of:

33 lb Phenol/1000f^3/day

= 15 Kg/28.4 m^3/day

= 0.528 Kg/m^3/day

say 0.528 Kg/m^3/day

as Vol of aeration chamber = 0.025 m^3

then loading required is 13.2 g phenol. If concentration is 100mg/l phenol the volume required is $\frac{13,200}{100}$ = 132 litres/day.

This can be achieved by filling three 20 litre containers and linking with syphons or obtaining 2 x 60 litre containers.

A similar procedure can be used when operating the rotating disc contactor. The loading rates should be increased over a period to establish a maximum value. By this means it should be possible to estimate the oxygen requirement and the volumetric loading.

eg. If plant will treat 0.528 Kg Phenol/m^3/day, and effluent has a phenol concentration of 100 mg/l (flow^3/240 m^3/day)

then amount of phenol is 240 x 1000 x 100 mg/day

$$= \frac{240 \times 1000 \times 100}{1{,}000{,}000} \text{ Kg} = 24 \text{ Kg/day}$$

ANNEX 7

LOW COST METHODS FOR DUST SUPPRESSION

1. Windbreaks - Installation of fencing (1-2 metres high) around stockpile of fine crusted material can reduce the effect of wind.

2. Shielding - Conveyors could be covered with a hessian shield to prevent wind blowing dust off the conveyor. The installation of a vertical cylindrical shield over the end of the conveyor will direct the fine particulate material downwards and reduce wind dispersion.

3. Dust Supression Sprays - Equipment and surface active chemicals are available to suppress dust at points of dust generation e.g. crusher discharge, conveyor transfer points, discharge to stockpile. The use of surface active agents greatly reduces the amount of water required and iproves 'wetting'.

4. Stockpile Dispenser - The conveyor is discharged into a clylindrical tube perforated with large holes at different heights. The dust falls to the ground in the first instance and as the height of the stockpile increases the cylinder begins to fill. When the next aperture is reached the dust slides out continuing the formation of the stockpile with minimum dust emission.

ANNEX 8

REQUESTS RECEIVED FROM PCRI

1. Acquisition of Standard Methods of Analysis.

2. Collection of information on polyelectrolyte dosing equipment.

3. Provision of information on polyelectrolyte manufacturers and local agents.

4. Visit to Indian High Commission to obtain lists of local agents.

5. Information of companies supplying dust suppression equipment.

6. Provision of information/flow sheet on the production of calcium carbide.

7. Supply of brochures on gas detection tubes.

8. Contact Bayer (UK) to obtain toxicity information on Lekutherm 18, Lekutherm Hardner, Plaaticizer.

9. Obtain toxicity data on trichlorethylene, zinc naphthenate.

10. Contact Sola Finishing Varnish C for toxicity data on conducting varnish 8003, semi conducting varnish 642 51B.

11. Obtain copy of Rideal/Stewart Modification for B.O.D. test,

12. Collect information on rapid qualitative tests for water analysis.

13. Contact Labor Instruments, Vienna, concerning cooling unit supplied with adiabatic bomb calorimeter.

14. Obtain literature on producer gas effluents.

15. Literature on Speciation Studies of metals in sediments/fly ash/soils.

16. Toxicological studies in industrial effluents.

17. Biological Control of Environmental Pollution.

18. Information on the use of enzymes in waste treatment.

19. Literature on the production of single-cell protein.

20. Literature on plants capable of capturing heavy metals.

21. Brochures on batch incinerators.

22. Brochures on high volume samplers.

Estimate time - 2 weeks including 250 km travelling.

ANNEX 9

U.N.I.D.O Fellowship

PARTICIPANTS (Provisional)

B Malik	-	Chemical Engineer
R Maheshswari	-	Civil/Environment Engineer
N G Shrivastava	-	Limnologist (Biology/Biochemist)
S N Shrivastava	-	Instrumentation/Electrical Engineer

PROGRAMME

Pollution Research Unit, University of Manchester
- Biological aspects of pollution
- Anaerobic Digestion of wastes
- Instrumentation, calibration, fault finding, repair
- Experimentation design/laboratory design

Water Research Centre
- Stevenage laboratory
- Water pollution research/Instrumentation

Leather Research Association - Experimental work on treatment of tanning waste.

Harwell Laboratory
- Analysis of environmental samples
- Analytical techniques and equipment
- Environmental Safety Group
- Visit to Landfill site

British Electricity International

Central Electricity Res. Lab
- Impact of Atmospheric Emissions
- PF Plant and EP's
- Coal Processing & Ash disposal
- Stack Emission Control Technology
- Instrument Engineering

Marchwood	-	Air dispersion modelling
	-	Environment impact assessment
Capenhurst	-	Electrochemical processer

Hewlett Packard

Training	HP1090 Liquid Chromatograph
	HP 5880A Series G.C. terminal
	3392A Integrator
	HP Gas Chromatograph

Estimated time required for discussions, including visits, 2 weeks plus 1250 kilometres.

ANNEX 10

SUGGESTED METHODS OF TREATMENT FOR WASTES FROM THE KOPPA KHEDA POWER STATION

Ash Pond Overflow - It was suggested that PCRI should always consider the possibility of water re-use when studying pollution control projects. In this case instead of discharging the overflow to river it could be returned to the power station for re-use in the production of fly ash slurry.

Some flocculation studies should be carried out to ascertain the most suitable flocculating agent, should it be necessary to remove finely divided suspended solids from the ash pond effluent. This work should be carried out using slurry obtained from a power station using coal from the same source as that likely to be used in the new power station.

If it is not possible to complete the flocculation studies in time for submission of the report (i.e. end of May 1988) it is suggested that provision be made for the inclusion of a packaged dosing unit in the effluent return line, for use as and when required.

Other methods of treating the overflow, should it be necessary to discharge the river and meet the consent conditions, were discussed and these included:

Land Irrigation
Micro Strainers
Flocculant/Settlement Tanks

It was also suggested that the river water quality should be examined to determine the 'background' level of suspended solids. It may be possible to have discussions with the Pollution Control Board to see if the limit for suspended solids could be relaxed. The argument for relaxation could include the points that fly-ash is a natural product, and that the suspended solids content of the river, especially during the monsoon season, is likely to be in excess of the standard set.

Boiler Blowdown - This could be returned to the raw water intake to the water treatment plant for re-use.

Demineralisation Plant Effluent - It is usual for this effluent to be collected in a holding tank and the pH adjusted (automatically) to between pH 5-8, before discharge. It could then be directed to the ash slurry system.

Cooling Circuit Blowdown - To be directed to the ash slurry system.

Oil Unloading/Storage Area - A covered unloading bay is suggested, with a sump under the railway lines to collect spills. Spills could then be pumped to storage. The storage tank farm shouldd be surrounded by a bund wall. It may be necessary to install an oil separator to treat any overflow from this bunded area that may occur during the monsoon season.