Journal of Environmental Sciences (China), Vol. 3, No. 2, pp. 1–10, 1991 ISSN 1001-0742

Development and experience in the monitoring, assessment and control of environmental pollutants in Hong Kong

Feng Yingsheng(Y.S.Fung)[1]

(Received September 26, 1990)

Abstract—The late start of environmental protection in Hong Kong was discussed in the light of problems encountered during the development of environmental protection legistration in Hong Kong for the past 20 years. The collaboration in monitoring and assessment of environmental pollutants between the University of Hong Kong and various governments were described in parallel with the progress in environmental protection in Hong Kong. The developments of new analytical techniques for environmental monitoring and analysis is given and their application in environmental control described. The joint projects in assessment and control of environmental pollutants carried out in collaboration with local industries and other organizations within and without the university are given and discussed. The problems and possible solution facing Hong Kong in development control equipment for small scale industries are discussed and areas of development identified. The development and experience in the monitoring assessment and control of environmental pollutants in Hong Kong are summarized and areas of difficulties are illustrated.

Keywords: monitoring of pollutants; assessment of pollutants; control of pollutants; small scale industries; urban pollution.

INTRODUCTION

Although the concern about the environment in Hong Kong had started early in the 1960s, no comprehensive legistration for environmental protection was in place until the 1980s. During this period of time, the economy of Hong Kong had grow up rapidly and perhaps it is not surprising to learn that economic development took priority over other matters till the environment can no loger sustain uncontrolled dumping of the pollutants. It is interesting to note that the first area of environmental concern is air pollution. The reason was based on economy as there was concern about safety in air travel due to the reduction in visibility around the Kai Tak Airport as result of coal burning in the factories and from nearby population.

In response to the above concern, a committee on air pollution was appointed in December 1966 with an aim to determine the caused of air pollution and to estimate, if possible, the

[1]Deparment of Chemistry, University of Hong Kong, Hong Kong.

extent of this air pollution and to recommend (1) What amendments or changes are required to make the Clean Air Ordinance, an effective ordinance to control air pollution, and (2) What additional statutory or other controls, if any, are needed outside the Clean Air Ordinance to cover fully the problem of air pollution (The Committee on Air Pollution, 1969). Later, the Environmental concern was broadened to include water and solid pollution and an Advisory Committee on Environmental Pollution on Land and Water (EPCOM) was set up and issued their first report in October 1972. The EPCOM had been appointed by the Governor to keep under review the state of the environment as regards land and water pollution in Hong Kong; and to broadly advise the Governor on the measures which might be taken to control such pollution (Advisory Committee on Environmental Pollution on Land and Water of Hong Kong, 1972).

In view of the increasing concern about the environment, the Hong Kong Government had set up a detailed Review in 1974 concerning with the environmental problems facing the territory (Bidwell, 1988). The review team was asked for recommendations on the legistrative and technical control required; structure of the implementing authorities; and an action programme that would be workable and affordable. Preliminary agreement on the results of the first stage of the review was reached in October 1975 and implementation started in July 1977 with the appointment of an Environmental Protection Advisor. In 1975, around eight government departments had some pollution control functions and as results of the budgetary constraints and the strongly expressed concerns of the individual government departments, a policy unit was set up without its own monitoring or enforcement officers that would exercise its controls through the unit.

As results of above, the Environmental Protection Unit set up in July 1977 had inadequate resources (with 5 staff initially) and much hampered by the lack of information, and to some extent by the lack of co-operation by other departments. This led to slow progress in the enactment of the legistration and most of the relevant ordinances were only fully enacted in the 1980s (Table 1). With recognition of the need of additional staff resources, the Environmental Protection Agency was established in 1981 and by 1983 had around 100 staff. To rationalize the use of staff and to bring responsibility for law enforcement to a single department, a new Environmental Protection Department (EPD) was created in 1986 and staff and resources from six government departments were brought together under the Director of Environmental Protection. At present, the EPD has an establishment strength of over 500 staff divided into 10 functional groups plus a public relations section.

Programme for the monitoring of air pollution was initially started in 1966 by the Industrial Health Division of the Labour Department for the determination of the concentrations of sulfur dioxide in the Hung Hom area (an heavily industrialized area in Hong Kong). Since the start of the monitoring programme for air pollutants, the University of Hong Kong had collaborated with the Air Pollution Control Unit in the Labour Department and subsequently the

Environmental Protection Department for more than ten years since mid-1970. Currently, our environmental activities can be classified into three areas, namely, environmental monitoring, environmental impact assessment and environmental control. Details on the activities of the above three areas are given in the following sections.

Table 1 Time scale for the enactment of environmental legistration in Hong Kong

Environmental legistration	Year of enactment
Waste disposal ordinance	1987
Noise control bill	1988
Oil pollution (land use and requisition) ordinance	1984
Air pollution control ordinance	1987
Air pollution control (furnaces, ovens and chimneys) (installation and alteration) regulations	1987
Air pollution control (restriction and measurement of smoke emission) regulations	1987
Air pollution control (smoke) regulations	1983
Air pollution control (appeal board) regulations	1983
Air pollution control (air control zone) (declaration) order	1986
Air pollution control (specified processes) regulations	1987
Air pollution control (specified processes) (Specification of required particular and information) order	1987
Harbour air control zone and Tsuen Wan-Kwai Chung air control zone statement of air quality objective	1987
Water pollution control ordinance	1980
Water pollution control (Tolo harbour and channel water control zone) order	1986
Tolo harbour and channel water control zone statement of water quality objectives	1982
Water pollution control (appeal board) regulations	1985
Water pollution (general) regulation	1986
Water pollution control (appointed days) order	1987
Minor amendments	1987

ANALYSIS AND MONITORING OF ENVIRONMENTAL POLLUTIONS

For the monitoring of the environment, a joint project known as SIMLA (Summer Investigation and Monitoring of Lower Atmosphere) was started between the University of Hong Kong and the Air Pollution Control Unit in the Labour Department in mid-1970. The projects involve a group of 6 to 12 students working during the summer vacation. Other joint projects were also held in collaboration with the Engineering Development Department of the Hong Kong Government. A list of the collaborated projects with various government departments is given in Table 2.

From the nature of the projects over the years, a clear trend of moving away from ambient monitoring of SO_2, NO_x, ozone and Pb in air in early 1980s to industrial effluent monitoring in recent years was indicated. This corresponds with the setting up of six monitoring stations by the EPD in 1981 to monitor the priority pollutants on a continuous basis, providing year-long

data on the quality of the environment. Thus, the effort of the SIMLA project was concentrated on monitoring of organic and inorganic compounds emitted from selected trades and industries under licence control in Hong Kong (Fung, 1989b). The idea is to obtain information on the emission rates of given chemical compounds before the establishment of realistic levels of control.

Table 2 Joint monitoring programmes in collaboration with government departments in Hong Kong

Government departments	Date	Title	Pages
Labour department	Nov. 1980	Monitoring of SO_2, CO, NO_2 and Pb particulate matter in Hong Kong Island Kowloon Peninsula and New Territories	46
ibid	Oct. 1981	ibid	78
ibid	Dec. 1982	The effect of local topographical and meteorological factors at the population centres near to the Power Plant at Ap Lei Chau on the dispersion of SO_2	42
Engineering development department	Jan. 1983	Chemical problems related to the Chai Wan Refuse Composting Plant	56
ibid	May 1983	Study of chemical problems related to Kwai Chung Incineration Plant	19
Labour department	July 1983	Analysis of total suspended particulate matter settleable dust and rain water collected in quarries and construction sites around Hong Kong	53
ibid	Dec. 1983	Survey of concentration of organic and inorganic gases and vapours emitted from six selected trades in Hong Kong Island, Kowloon Peninsula and New Territories	80
ibid	Dec. 1984	The on-site verification of the impaction formula for calculating the SO_2 concentrations at buildings near to the emission sources	27
ibid	March 1985	Survey of concentration of organic and inorganic compounds emitted from selected trades at various factories in Hong Kong Island, Kowloon Peninsula and New Territories	83
ibid	May 1985	Sampling and analysis of gases and particulates emitted from stacks of power plants, cement factory and asphalt paving plant	29
Environmental protection department	April 1986	Investigation of the effect of stack and fugitive emission of gases, vapours, toxic metals and particulates from ceramic, clay, dyeing, lead and steel work, aluminium smelting and scrap metal recovery plants	60
ibid	April 1987	Characterisation of the chemical composition of the particulates and gases emitted from stacks of incinerators and power plants in Hong Kong	97

In parallel with the monitoring programme, we had developed sensors and analytical techniques needed for environmental control and assessment. The list of projects is given in Table 3. The projects can be broadly classified into two types. The first type is the development of new analytical techniques for given analysis and the second type is towards the application of analytical technique to solve a given analytical problem.

Table 3 List of projects in analysis of environmental pollutants

1.	Analysis of organic vapours using piezoelectric crystal sorption detector
2.	Development of non-suppressed Ion Chromatography using UV-visible and fluorescence detectors
3.	Application of square wave voltammetry for flow injection analysis with the use of micro-computer
4.	Development of voltammetric and other electrochemical techniques for trace analysis application (note a)
5.	Speciation of mercury in sediment using Atomic Absorption Spectrophotometry (note b)
6.	Analysis of Polycyclic Aromatic Hydrocarbons in air particulates with HPLC, UV/Vis Diode-Array and Fluorescence Detection (note c)

Note:

a. in collaboration with Electroanalytical Group, Zhongshan University, China.

b. in collaboration with the Government Laboratory, Hong Kong Government.

c. in collaboration with Hewlett-Packard Asia Ltd.

The former approach is explorative in nature, with a hope that the method to be developed will be better than the existing method used. The second approach places stress on reliability, practicability and applicability of given analytical procedures. It involves studies in sample preparation and interference studies of the sample matrix. The working experience of the users of given analytical procedures is important to establish the workability of given analytical technique.

For new analytical methodology deve- lopment, three techniques are currently being developed in our research group. The first technique is the development of a piezoelectric crystal sorption detector for vapour analysis (Lee, 1982b). It makes use of the principle that the vibration of a given piezoelectric crystal is dependent on the mass at the surface of the crystal. Thus, by coating the surface of the crystal with a selected material that interacts with the analyte of interest, the concentration of that analyte can be determined by measuring the change in frequency of the vibration according to the following Sauerbrey equation.

$$\Delta f = M\Delta W,$$

where M is a constant whose magnitude is determined by the frequency of the oscillating plate, the frequency constant of the crystal cut, the density of quartz and the effective area of the vibrating plate; ΔW is mass deposited on or removed from the surface of the crystal; Δf is change in the resonant frequency.

The method is simple, inexpensive and sensitive and thus an ideal technique for use a sensor for automatic monitoring of given air in a factor or in chemical processing. We are at present developing this technique as a sensor for organic vapour control in our environmental project and as group selective detector for capillary GC.

The second technique developed in our research group is non-suppressed ion chromatography(IC). As the result of the demand for rapid analysis of trace amounts of ions in complex matrix, the IC technique had emerged as an important technique in recent years. However, the sensitivity of the non-suppressed I is an area that needs improvement in order to extend the scope of application.

Traditionally, the ion eluted from IC is detected by the conductivity detector which is inherently less sensitive, especially against background with high conductivity. To reduce this limitation, the approach we have taken is to chemically modify the composition of the eluent so that we can convert the ions to a form detectable by the use of UV and fluorescence detectors (Tam, 1988). On the separation side, we have synthesized the styren-divinlyl benzene copolymer and functionalized its surface with active groups, with the aim of separating analyte ions from a matrix containing a high salt content, such as seawater or the solution obtained after acid digestion.

The third technique is the development of electrochemical techniques for flow injection analysis (Fung, 1989b) and for trace analysis. The stress is on automation of the analytical technique and to achieve maximum sensitivity so as to lower down the detection limit. The use of microcomputer for the generation of required waveform and for data acquisition and manipulation is essential for the success of this approach. The square wave voltammetry is selected as it is less sensitive to the variation of flow rate during the analysis.

Regarding applications, the research work is mostly done in collaboration with laboratories or organizations outside the university (Lee, 1982a, 1988a). The share in expertise, equipment and resources among the participating groups made the research most successful and benefit to both in the long run as we can obtain the input of practical experience while we develop our analytical method, and at the same time providing a service to the community which supports us.

ENVIRONMNETAL IMPACT ASSESSMENT

For assessing the impact of major pollution sources in Hong Kong, the causes of the problems had to be identified first so as to assist the setting up of priority for control purpose (Fung, 1986, 1987a, 1987b, 1988b). Currently, there are three ongoing projects carried out in our research group. The first project is using the receptor model approach to apportion the relative contribution of different pollution sources to the pollutant levels received at a given receptor site. The method involves obtaining the chemical compositions at the receptor site and at the major pollution sources so as to obtain their fingerprint signature. By employing

statistical analysis, one can calculate the relative contribution of different pollution sources at the receptor site. A joint project with the Scientific Service of China Light & Power had been started using the above approach in 1985 and the preliminary results obtained are very promising (Fung, 1987c, 1988c, 1989d).

The second project is in collaboration with the Centre for Environmental Studies, Department of Applied Biology and Chemical Technology, Hong Kong Polytechnic. It involves measuring the pollutant profile in the bottom sediment at various sites off the seashore of Hong Kong. Coupling the results in parallel with the Pb-210 dating, we can determine the pollution history in the past years of Hong Kong (Lo, 1988). Knowing the rate of increase in the pollutant levels and their distribution in different seabeds in Hong Kong, one can obtain sufficient information to make decisions to control the discharge of these pollutants realistically.

The third project in collaboration with the Paediatrics Department of the University of Hong Kong. From our previous survey on the lead content of fishermen's children in the Aberdeen area, it was found that they had large concentration of lead in their blood as compared with children who live on land. As a high level of lead in blood can reduce the intellectual development of the child, we are conducting a more comprehensive survey of the fishermen's children with the aim of obtaining confirmatory data and submitting it to the government for proper action, and to identify the environmental factors that contribute to high lead level in the blood of fishermen's children.

ENVIRONMENT CONTROL

As most industry in Hong Kong is very small in scale (Fung, 1988b, 1988e) and housed in multi-story industrial buildings, the control of the emission of industrial waste is a major problem. Most of the air or water pollution control equipment developed in the west is either too costly or too big to be used in Hong Kong. Thus, in collaboration with the Environmental Management Division of the Hong Kong Productivity Council, we start a project for the development of air pollution control equipment suitable for small scale industry. The equipment developed must be small, economical and less dependent on operator skill. Thus in parallel with the development of the control equipment, we are also investigating new auto-analyser suitable for control purposes. A list of the projects for environmental assessment and control is shown in Table 4.

For controlling air pollution from small scale industry, there are two areas of development at present. The first area is to develop small scale odour control equipment as odour problem is the most frequent complaint in Hong Kong due to the high population density and the proximity of residential area to the industrial area. The second area of development is the use of dry sorbent for air pollution control. The use of traditional wet scrubbing method will take up considerable space and gives rise to water pollution problem which is not easy to tackle by a small scale industry which can not afford the manpower to handle the rather complicated

control equipment.

Table 4 List of projects in environmental control and assessment

1.	Apportionment of air pollution sources using the receptor model with trace metals as the markers (note a)
2.	Resolving the heavy metal pollution profile by means of Pb-210 dating technique (note b)
3.	Survey of lead levels in fishermen children's blood (note c)
4.	Monitoring and control of emission of organic vapours from small scale industries in Hong Kong (note d)
5.	Survey of the organic and inorganic compounds emitted from selected trades and industries in Hong Kong (note e)

Notes:

a. in collaboration with the Scientific Services Branch in China Light & Power Company Ltd.

b. in collaboration with the Centre for Environmental Studies, Department of Applied Biology and Chemical Technology, Hong Kong Polytechnic.

c. in collaboration with the Department of Paediatrics, Faculty of Medicine, Hong Kong University.

d. in collaboration with the Environmental Management Division, Hong Kong Productivity Council.

e. in collaboration with the Air Pollution Control Unit/Division in the Labour Department/ Environmental Protection Department.

The major problems for environmental control for small scale industry in Hong Kong is the frequent change in product lines and subsequent different characteristics of the effluent. The lack of incentives as result of the exemption of existing industries from the new environmental protection legistration leads to inactivation of the factory concerned. The worsening of the environenmtal quality as indicated by the frequent deviation from the air and water objective guidelines set up by the EPD gives a clear signal that the current legistration needs to be tightened. With the recent increase in the number of staff in the EPD, the legistration should be enforced more frequently and we hope that with the development of a suitable and affordable environmental control equipment, it will provide sufficient pressure to the industry concerned to adopt a more positive attitude towards environmental protection in Hong Kong.

CONCLUSION REMARKS

The work described in this article is mainly those carried out in association with the author's research activities. It is not intended to provide an extensive coverage of the environmental work carried out in Hong Kong. Rather, it focuses on the contribution of a chemist towards environmental protection, in particular, in the area of analytical chemistry.

In the three areas described, namely, the analysis and monitoring, environmental assessment, and pollution control, our experience indicates that for an urban area like Hong Kong

with high density of high rise buildings and considerable intermixing of residential and industrial areas, the apportionment of pollution source is important for establishing priority of control. However, the complicated topology and the occurrence of multiple sources within a few kilometers make mathematical modelling extremely difficult, if not impossible, to give realistic estimate. The location of various different factories within a multi-story industrial factory creates a big problem for controlling emission from industry. Pooling of similar industries within specific zones may be the answer as communal treatment facilities can be installed and cost spread out to several manufactures. The government should take a lead in the co-ordination of above and put more stress on environmental protection during the urban development and city planning as many of the faults occurred now is the results of a poor or lack of planning in the past.

With regard to the various joint projects undertaking with the government and other organizations, our experience indicates that the collaboration in environmental work leads to the sharing of resources and expertise. This certainly will speed up the progress of the work and make the project feasible with short lead time. This is evidenced by the fact that most of projects described are carried out in the past nine years. Perhaps, the late start in the environmental protection legistration in Hong Kong leads to a concentrated effort within a short period of time.

Looking at the projects conducted up to the present, it is a noticeable absence of collaboration with the environmental groups in China. Although Hong Kong and China are close geographically, socially and culturally, the difference in the two systems and the lack of communication prevent interaction and collaboration in environmental protection work. However, as air does not recognize boundaries and the rapid industrialization in Hong Kong and the neighboring areas in recent years would certainly lead to concern about long range pollutant transport in the near future. A closer collaboration is greatly needed to foster communication and enhance exchange of information and data needed for the protection of the environmental for both Hong Kong and China.

Acknowledgements—I would like to acknowledge the collaborators, former students and others who have contributed their efforts for the various projects mentioned. Special thanks should be extended to Dr. K.W. Fung for his pioneering work in setting up analytical chemistry research work in the Chemistry Department of Hong Kong University, and also his continuous support and encouragement. I would also like to acknowledge support from the following bodies over the years: Committee on Research Grants, Hui Oi-Chow Trust Fund Committee, Run Run Shaw Research & Teaching Endowment Fund, Air Pollution Control Division, Productivity Council, China Light & Power Co.Ltd., Instrumentation Laboratory (Far East) Ltd., Hewlett-Packard Asia Ltd., and other firms and organizations donating to the Analytical Chemistry fund over the years.

REFERENCES

Advisory Committee on Environmental Pollution on Land and Water, In: First Report of the Advisory Committee on Environmental Pollution on Land and Water—October 1972, Hong Kong Government Press, 1972

Bidwell, R., In: Proc. Pollution in the Urban Environment POLMET 88, 1988, 1:18

Fung, Y.S., Environ. Int., 1989a, 14:501

Fung, Y.S., and S.Y.Mo., The application of square wave voltammetry for electrochemical detection of ascorbic acid in flow injection analysis (The paper 173 presented to the 40th International Society of Electrochemistry Meeting), 1989b

Fung, Y.S., D.T.W.Ting and K.W.Fung, Fresenius Z. Anal. Chem., 1988a, 331:490

Fung, Y.S., Some Selected Air Pollution Problems in Hong Kong, Proceedings of Seventh World Clean Air Congress, Sydney, Australia, 1986, 5:128

Fung, Y.S., J.Hong Kong Institution of Engineers, 1987, 15(5):33

Fung, Y.S., Assessment of Air Pollution in A Dense Populated City, Proceeding of the Eightieth Annual Meeting of Air Pollution Control Association (U.S.A), 1987b, 87(106B):1

Fung, Y.S., In: Proceeding of Conference on the Prospects for Hong Kong's Chemical Process Industries in the Changing Environment, Hong Kong Chemical Society, 1988b, 2:79

Fung, Y.S., In:Proceeding Paper at 1987 Asia-Pacific Conference on Pollution Control and Clean Air, 1987c, R1

Fung, Y.S., Extended Abstract of the International Conference on Tropical Micro-Meterology and Air Pollution, 1988c, 139

Fung, Y.S., L.W.Y.Wong and C.J. Muskett, In: Proceeding of POLMET 88 International Conference on Pollution in the Urban and Metropolitan Environment, 1988d, 1:321

Fung, Y.S., Chemix, 1988e, 1(3):16

Lee, C.W., Fung, Y.S. and Fung, K.W., Analyst, 1982a, 107(1270):30

Lee, C.W., Fung, Y.S. and Fung, K.W., Anal.Chim.Acta, 1982b, 135(2):277

Lo, C.K. and Fung, Y.S., In: Proceeding of Symposium on Environment and Cultural Heritage, 1988, June 6

Tam, W.M. and Fung, Y.S., In: Proceeding of Symposium on Environment and Cultural Heritage, 1988, June 6

The Committee on Air pollution, A Report on Air Pollution in Hong Kong—August 1969, Hong Kong Government Press, 1969