The University of Calgary

Evaluation of the Effectiveness of Effluent Charges in Wastewater Pollution Control: a Case Study Conducted in Xinyu, China

by
Yanhua Chen

A Master's Degree Project submitted to the Faculty of Environmental Design in partial fulfilment of the requirements for the degree of Master of Environmental Design (Environmental Science)

Calgary, Alberta

The University of Calgary

Faculty of Environmental Design

The undersigned certify that they have read and recommend to the Faculty of Environmental Design for acceptance a Master's Degree Project entitled "Evaluation of the Effectiveness of Effluent Charges in Wastewater Pollution Control: a Case Study Conducted in Xingyu, China" submitted by Yanhua Chen in partial fulfilment of the requirements for the degree of Master of Environmental Design.

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Abstract

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The challenge in pollution control is to achieve and maintain a high quality environment without hindering economic progress. The cost of environmental regulation is now rising very rapidly. Consequently, there is an urgent need for regulatory reform to reduce excessive compliance costs and make environmental controls more effective. Establishing economic instruments such as effluent charges to supplement command-and-control methods of regulation is necessary under the new economic open policy.

This study focuses on evaluating the effectiveness of levying effluent charges on industries which discharge wastewater into a waterbody by a case study conducted in the middle-sized city of Xinyu in Jiangxi Province of China. Current policy instruments practised in China for achieving water quality objectives are described. The effectiveness of effluent charges is examined by conducting interviews with a key informant from the environmental regulatory agency and with sixteen correspondents from the industries discharging wastewater into the major river of

the city, Yuan River. The interviews consisted of three aspects for evaluating the effectiveness of effluent charges: the profile of each industry for understanding the background, the problems that might occur and the response behaviour changes which reflect the effectiveness of effluent charges.

Among the conclusions are that the successes of applying effluent charges are its acceptability by industry and its fund-raising potentials. Effluent charges are considered to be only partly effective because of low charge rates. But the development of water the technology market, which has grown rapidly and is now the largest segment of the environmental protection market, might also indicate that effluent charges have made at least some contribution to technical innovation. Improvement of effluent quality has been achieved with respect to cyanate and suspended solids, but not with biological oxygen demand.

Although water quality in the Yuan River has improved since the charge system has been in operation, it is hard to assess the system's effectiveness in isolation from direct regulation and negotiation. Successful implementation of effluent charges depends on the extent and degree of behaviour change of the target group,not only the enforcement by laws and regulations, but also by the use of social pressure and moral suasion, such as the degree of media attention and public support, and by the financial support or resources from other departments of the government.

The report suggests moderate increase in charge levels, with site-specific effluent standards in terms of the assimilative capacity of the river in order to ease the implementation of effluent charges and strengthen their effectiveness. It stresses the importance of some measures: setting different levels on the concentrations of discharges from industries, and controlling the location of discharges and industries.

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1 Introduction

Controlling industrial wastewater is one of the major tasks of the environmental protection objectives in China. The government of China has planned to have a significant reduction of discharges from industries by year 2000, with surface water quality controlled at the same level as in the beginning of the 1990s.

PROBLEM STATEMENT

The use of effluent charges to control wastewater pollution in China in recent years has been a substantial departure from the traditional implementation of policy regulations. Effluent charges in China have been designed as an instrument to assure adherence to the effluent standards, that is, to provide waste producers with economic incentives to reduce waste discharges in order to meet environmental objectives. Another goal of using effluent charges is to raise revenue for pollution abatement. "the policy process is about the definition of public problems, the forging of means to deal with them, the implementation of a solution, and the monitoring of success or failure. If the monitoring uncovers further problems, then the process goes through the loop once again." (Pal, 1987, p107). Hence, it is necessary to evaluate the effectiveness of this policy instrument, for meeting these two purposes and for gaining more theoretical and empirical experience to make the best choice of pollution control policy instruments. The definition of "effectiveness of effluent charges" in this study is that using effluent charges can bring about environmentally responsible behaviour, such as improving activities in wastewater control and effluent quality.

An evaluation of the effectiveness of using effluent charges on water quality control was conducted through a case study in Xinyu City, Jiangxi Province, China. The research problem is:

> Water pollution caused by various industrial/economic activities in
> the area and the questionable/uncertain effect of effluent charges as a control instrument on water pollution.

OBJECTIVES OF THE STUDY

The objectives of this study are to evaluate the effectiveness of effluent charges by studying whether the two goals of using this instrument have been achieved, and to analyse the problems if the goals have not been met. The study should provide experience on using effluent charges in middle-sized industrial cities, with one major industry and other auxiliary industries. The study should also present insight into better future applications of effluent charges and other economic mechanisms on pollution control.

In order to achieve these objectives, the goals of the study are:

1. to identify the instruments mainly used for meeting water quality policy objectives,
2. to recognise the causes for negative polluters' behaviour change,
3. to recognise the response behaviour changes from industries to effluent charges, and
4. to provide insight into future applications of alternatives, by explaining the impacts of effluent charges on pollution control and giving suggestions for better implementing effluent charges.

SCOPE OF THE STUDY

The contents are divided into seven chapters. The first chapter contains a brief overview of the context for the study, the problem statement, the objectives of the study and the scope of the analysis.

Chapter 2 is a literature review, discussing previous investigations and studies on the same or a closely related subject and reviewing briefly the theory related to effluent charges. The circumstances in which economic instruments have been applied to supplement regulatory policy instruments are stated. A theoretical basis of conducting this study and the basis of the methodology in this study are presented.

Chapter 3 contains the policy context. Not only is the tendency of using effluent charges under the general circumstances in the whole country described, but also the links between the country-wide situation and the local situation.

Chapter 4 contains the methodology of the analysis. The main issues which need to be assessed in evaluating effluent charges are set out. First, it contains the sampling design, then a discussion of the research tool, the questionnaire. Finally, the data collecting process is provided.

Chapter 5 contains the instruments used for implementing water quality policy. There are three important policy instruments for water pollution control. One is the traditional command-and-control type of instrument, regulations. The second type is effluent charges, designed as an instrument to assure adherence to the effluent standards. The third type is negotiation, a sub-formal instrument to solve some pollution problems by bargaining between government and industries.

Chapter 6 is the profile of the study area. A general description of Xinyu City, including the population and economy of the city, the climate, the environmental management and status of Xinyu City are provided. The annual average wastewater flow, amount of cyanate, biological oxygen demand and suspended solids produced from the industries are given. Based on these data, the main producers of CN^-, BOD and SS are found.

The problems that might result in negative response behaviour to effluent charges are identified, and the results from the interviews related to these three causes are presented in Chapter 7: 1) problems in law-making process so that industries don't accept the effluent charges levyed on them, 2) low charge level which has no incentive function and 3) enforcement problems in regulatory agency, such as industry's ability to pay for the charges, economic and political desirability of the project or industry, the ambiguity of the rules to collect charges and the junior status of the environmental regulatory agency.

In response to the problems which might result in negative response changes in pollution control activities from industries, Chapter 8 contains response behaviour changes from industries to effluent charges: pollution control activities and the change of effluent quality.

Chapter 9 contains conclusions from the analysis of the report, identification of the main issues in the use of effluent charges, and provides a number of specific recommendations which may be helpful to the application of economic instruments.

2 Literature Review

BRIEF THEORY REVIEW

Definition and Mechanism of Effluent Charges

A number of terms are used to describe economic instruments, for example, "market mechanisms", "market-based instruments", "incentive mechanisms", "economic incentives". Economic instruments might be better described as "incentive mechanisms". As one of the economic instruments, charges could be levied on total discharges, or on discharge in excess of some baseline, in various ways. They could vary by location, reflecting their reaction to environmentally sensitive areas, or they could even vary in respect to weather conditions, since weather conditions might influence where wastewater should be discharged.

Effluent charges are costs that attach to pollutants released from industries or firms. Charges are collected on an activity or paid for its performance (Tietenberg, T. H., 1994). The charges are calculated on the basis of the quantity and/or quality of discharged pollutants. Effluent charge is a type of market instrument, used as a tool for implementing and enforcing environmental protection policy. "Many economists have advocated the use of economic instruments as they were expected to provide environmental policy-making with flexible, effective and efficient options in realising its objectives." (OECD, 1989). The mechanism of effluent charges is based on a simple model of conventional economic analysis.

For example, the marginal cost of the effluent treatment for each company will increase with the increase in percentage of the wastes removed from effluent (Figure 1). The company is expected to treat its effluent to the point where the marginal cost of treatment equals the effluent charges, for example, point X in Figure 1. Therefore, the regulatory agency responsible for charge setting can directly influence the corporate response of the company in abatement of effluent by the adjustment of charges. A theoretical attribute of effluent charges is to provide a continuing incentive to improve environmental quality, in that the company is motivated to meet required standards at least charges. In addition, the development of new and less expensive treatment technology may shift the intersection of the marginal cost curve and the effluent charge to a higher level of treatment.

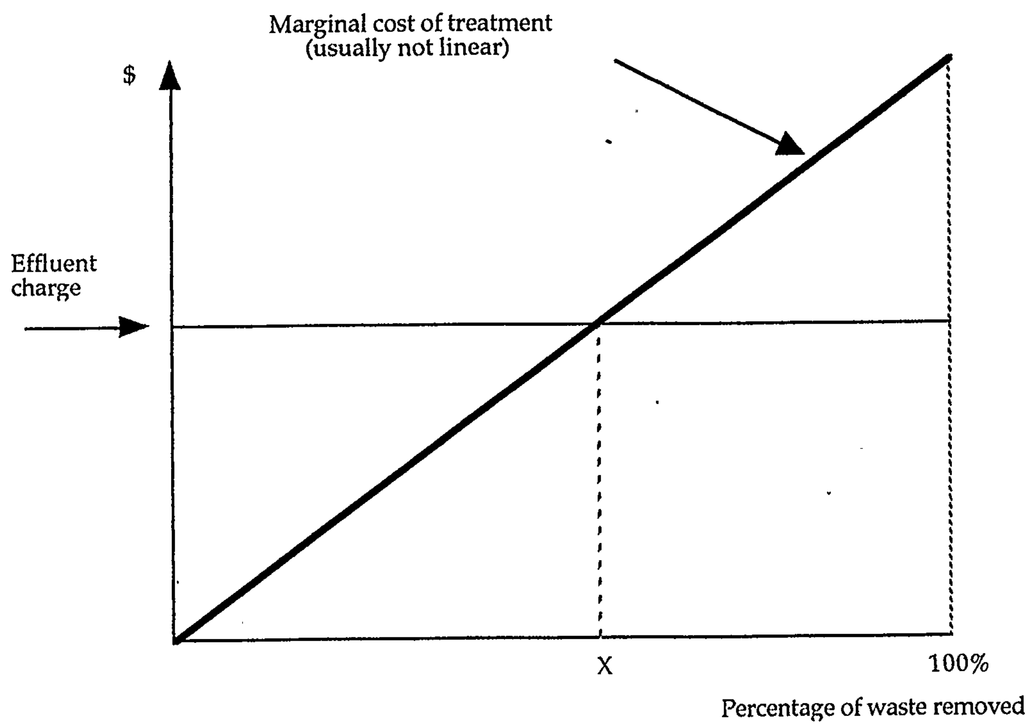

Figure 1: Mechanism of Effluent Charges

The Logic of Effluent Charges

The water systems may be treated as a free medium for disposing harmful wastes without taking external costs into account. Polluters might impose the costs from environmental externalities on other members of society. There has been a need for government intervention to restrict environmental externalities. In economic terms, environmental policy should make a balance between the costs of pollution and the costs of restricting pollution, that is, pollution should be controlled up to the point where the marginal cost of further abatement measures just outweighs the gain from reduced emissions. This means, in practical terms, that environmental policies cannot rely on simple all-or-nothing forms of intervention, but instead must be able to accommodate a more complex equation between different interests (Fox, 1979). An efficient pollution control policy would seek to reflect these individual differences in abatement cost, and would concentrate abatement measures where reductions in pollution can be achieved at least cost.

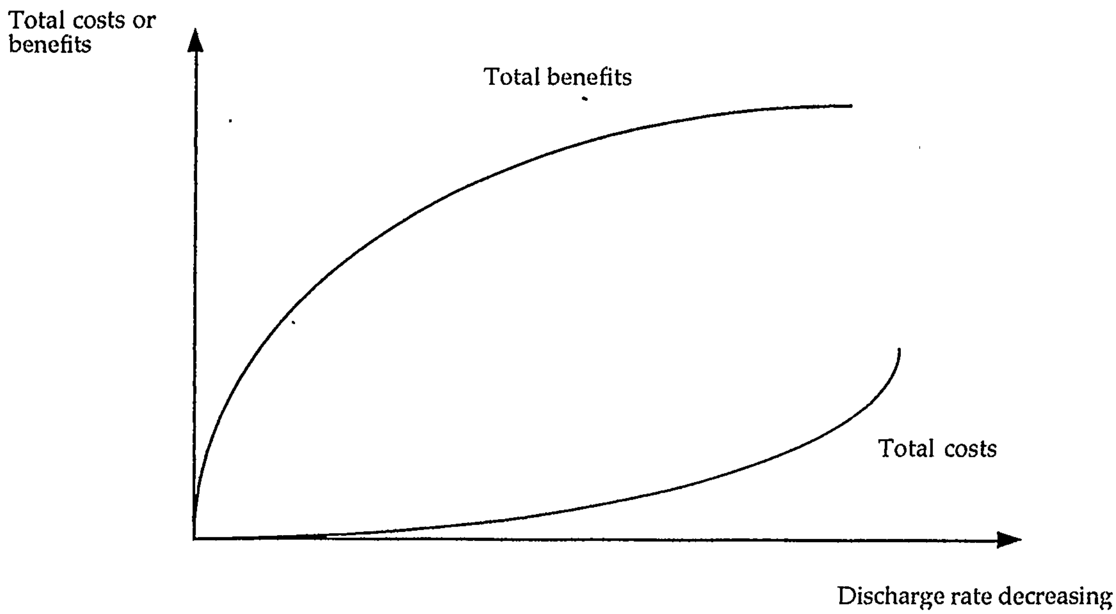

Figure 2: the Relationship between Total Environmental Benefits, the Total Control Costs and Pollution Control Goal

Source: Dorcey, Policy Mechanisms for Water Quality Management, p259

A key concept to use effluent charges is "economic efficiency". According to the theory of environmental economics, an economically efficient wastewater control policy would set discharge reduction target maximising the net benefit achieved by reducing wastewater and minimising the cost of the resources needed to bring about the reduction. The condition for achieving this optimum is that the marginal environmental benefits of reducing wastewater are equal to the marginal costs of reducing the emissions responsible for it. Figure 2 shows that the total environmental benefits and the total control costs increase as the pollution control goal is higher.

The condition to minimise costs of reducing wastewater discharges by any particular amount is that the total resource costs of achieving a desired reduction is shared across polluters in such a way that the marginal costs of abatement of each polluter are equalised.

One of the advantages of effluent charges is efficiency in both static and dynamic ways because this type of instrument can minimise the cost of achieving pollution control objectives and can encourage technology innovation as permanent incentives to control pollution. The second advantage of using economic instruments is the flexibility both to polluters who are free to adapt to market signals and to environmental policies. Collecting revenue contributing to government budgets or to pollution abatement projects is the third advantage of economic instruments. Two main drawbacks of effluent charges are the problem of choosing the charge levels and the complexity or high cost of management to use effluent charges; discharges from industries are sensitive to the charge levels. Small errors in predicting industry's charge-response relationship could result in a large mistake in controlling effluents. In addition, using effluent charges requires complex information, such as the determination of the sources of pollution, the total pollution load discharged, the assimilative capacity of the receiving water, and an accurate monitoring system (OECD, 1993).

Criteria for Choice of Effluent Charges

OECD (1991) stated six criteria for choice of emission charges (including effluent charges). Effluent charges should be given particular consideration for: 1) stationary sources, 2) variation of marginal abatement costs across polluters, 3) the feasibility of monitoring emission, 4) the ability of polluter to react to the charge, 5) the ability of public authorities to develop a consistent framework for charges, and 6) the potential for technical innovation.

Purpose of Using Effluent Charges

According to the economic analysis, the purposes of using effluent charges are to change polluters' behaviours towards better environment quality by providing financial incentives for a reduction in the discharges of effluent and to raise revenue. Effluent charges aimed at changing polluters' behaviour toward better environment quality are likely to be more complex than those only designed for revenue-raising purposes, because it requires the determination of the sources of pollution, the total pollution load discharged, the assimilative capacity of the receiving water, and the accurate monitoring system.

From the standpoint of water quality management, the purpose of using effluent charges is to reduce total discharge, to change the distribution of effluents by time and place (preventing peaks of concentration of pollutants), to relocate industry away from population centres, and to stimulate new pollution control technologies.

Price Determination

The conventional economic analysis of water quality management indicates that an efficient wastewater pollution control mechanism would maximise the net benefit by reducing wastewater and minimise the cost of the resources needed to bring about the reduction. The condition to achieve this efficiency is that the marginal benefits of reducing wastewater are equal to the marginal costs of reducing discharges. The approach to set charge level is based on this efficiency concept, to equalise the costs of environmental protection with the damage cost after reducing wastewater (benefit) by putting a price per unit on effluent. But this is not easy to achieve because certain environmental damages cannot be measured by money.

At the optimal level of water quality , the marginal cost of pollutant management is equal to the marginal damage, as shown in Figure 3. In practice there are significant uncertainties about the shape and position of both functions, not only because of the variation inherent in natural and technological systems, but also because of the limitations on the understanding of physical, biological, and chemical processes of pollutants in the ecosystem, and the uncertainty for measuring human values associated with these.

Dorcey (1978) illustrated these variations and uncertainties graphically (Figure 3) by a zone of ABCD, somewhere within which the optimal level of water quality is defined.

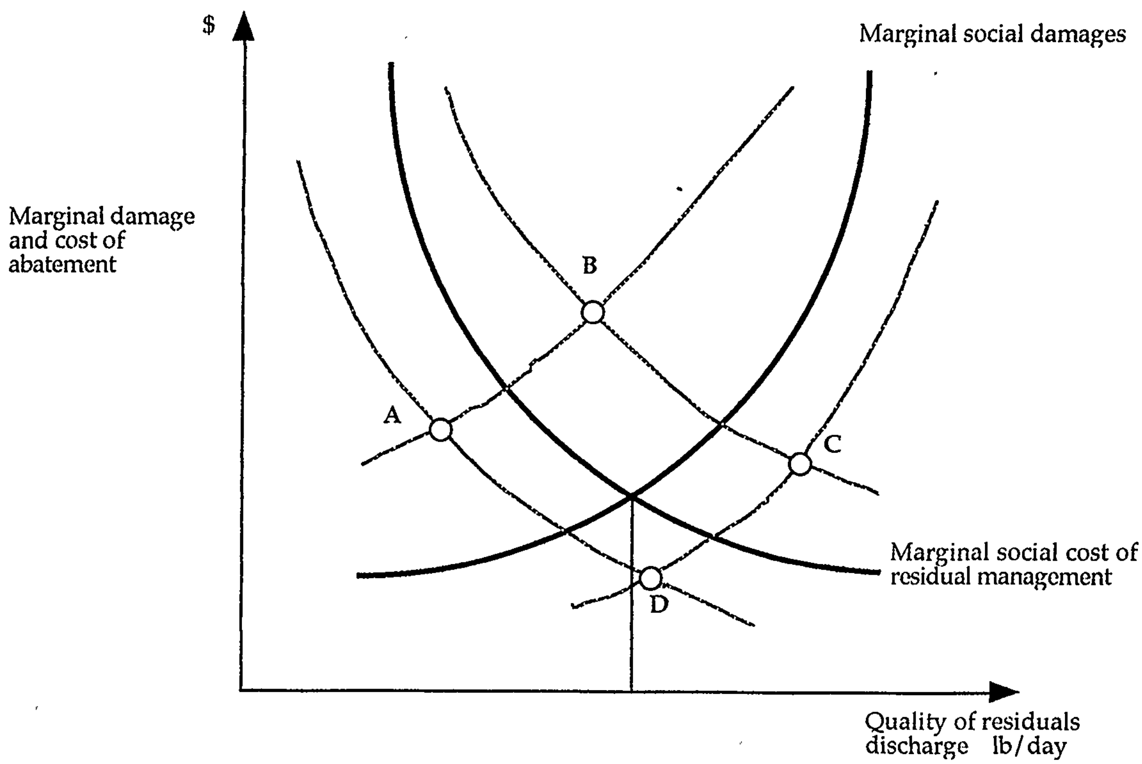

Figure 3: Uncertainty of the Function of Marginal Cost and Damage of Pollutants

Source: Dorcey, Policy Mechanisms for Water Quality Management, p259

The forms of charge can be "increasing block rates" by setting threshold values of quantity of effluents. The charge remains moderate up to a certain concentration and thereafter increases rapidly (OECD, 1993). A second form is a linear relationship between charges and damage, proportionate to the total damage if a money value can be put on the damage caused by a unit of pollutant.

While not knowing the cost of the damage, a method to set charge level is first to set a limited quantity of pollutant, then set a price to get effluents down within that predetermined limit. If the charge is too high or too low, the price can be adjusted up or down (Bower et al, 1985). But this method might take a long time to define a proper charge level.

The setting of effluent charge levels in China can be described as increasing block rate based on 29 groups of pollutants, specified in the effluent standards. For example, suspended solids, BOD, COD, phenol, heavy metals. The first block covers the quantity of pollutants under the threshold values, the effluent concentration set in effluent standards and permitted amount of effluents, according to the regulation "Maximum Permitted Amount of Discharges for Various Industries". The second and the third blocks include effluents in excess of the threshold value. The charges rise faster with higher amount of pollutants discharged.

PREVIOUS INVESTIGATIONS AND STUDIES ON EFFLUENT CHARGES

Since the 1970s, different types of studies about the effectiveness, efficiency and the management feasibility of economic instruments have been conducted. The approaches varied according to the characteristics of the study, including cost-effectiveness and cost-benefit to evaluate the feasibility of using economic instruments in administration, collecting information, control effectiveness or pollutants management. Some case studies were done by considering the ideological or philosophical aspects of the instruments, the value of environmental quality and the value people attribute to environmental quality. Other studies were undertaken by using the rapidly growing water technology market and technical innovation as indicators to evaluate the effectiveness of the instruments, or by using pollutants as parameters to find the contribution of economic instruments to control certain pollutants.

In the early 1970s, economic instruments were used in very rare instances. There were few significant cases -- probably the most important were the water management systems in France and the Netherlands, implemented in the late '60s - early '70s, which rely heavily on waste water pollution charges (OECD, 1989). An early study of effluent charges applied to the Wisconsin River Basin management in

1970 was reported by Fox (1970). The conclusion was that effluent charges would be inefficient and administration infeasible because of lack of information related to setting charges and complex administration system.

Although effluent charges are imperfect in some aspects, for example, the charges are usually not high enough to achieve environmental goals because there exists a gap between theory and practice when collecting charges from industries, the advantages of collecting revenue and providing incentives to change polluters' behaviours cannot be neglected. More and more countries have used this system as a systematic environmental tool to meet their water quality objectives. In 1976, the United Nations published a report entitled "Principles and Methods for the Provision of Economic Incentives in Water Supply and Waste Water Disposal Systems". It included a survey of economic incentives used in water resource management in 21 individual ECE member countries from Europe to North America. The report concluded that the payment of charges for water pollution is an accepted principle and the charges are levied according to local conditions at a great number of different rates. Mostly they are fixed according to the principle that the "polluter pays". In general the charges may act as a stimulus for reducing the quantity of waste waters, their toxicity and pollution content. In this way it contributes to their protection against pollution (United Nations, 1976).

Dorcey (1977) did a study about policy mechanisms for water quality management in greater Vancouver and the Fraser Estuary. The focus of the study was to evaluate policy instruments (including economic instruments) for controlling residuals that enter the river. The evaluation was assessed in terms of the impact on economic efficiency, the cost-effectiveness, and the effect on the distribution of income of policy instruments. The assessment was made according to the information available about the receiving environment and residuals production in the metropolitan area, the damages caused by residuals entering this water environment, the costs of residuals management, the nature of potential environmental management plans, the administrative costs of alternative mechanisms, and their control effectiveness.

Steven Kelman (1983) believed that decisions to use economic incentives as a policy tool in any area of public policy, including environmental policy, cannot be evaluated on the basis of their efficiency advantages alone. "Such decisions may make the society less attractive in other respects". He discussed an interview including Washington-based participants in environmental policy formation in early 1978. The responses from respondents to charge proposals was a general ideological or philosophical attitude toward the market and toward government. "The interviews showed little knowledge of the nature of the efficiency argument for charges favouring markets and opposing "government interference." (Steven Kelman, 1983, p 13)

Kelman's study showed that supporters of the application of effluent charges rejected the conventional theory that charges were theoretically appealing but administrationally unachievable. Opponents of charges were unfamiliar with the efficiency arguments but worried about the effect of moving from standards to charges on the political prospects for maintaining strong environmental laws. The worries about charges being a "license to pollute," reflect the concerns that placing environmental quality into the market system would lower the perceived value of environmental quality for many people. This in turn would tend to lower the purpose in government policy, a function of the value people attribute to environmental quality.

The most systematic documents about economic instruments have been researched and published by OECD (Organisation for Economic Co-Operation and Development), including guidelines for introduction, design, and enforcement of economic instruments, including effluent charges, as environmental policy tools (OECD, 1991). Case studies were carried out by researchers in France, Germany and The Netherlands. In the French effluent charge system, all the actors polluting seawater or fresh water are liable to pay the pollution charges. The charge basis includes suspended solid, oxidisable matter, soluble salts, inhibitory matter, organic/ammonia nitrogen and total phosphorus. The purpose of the charge system is purely revenue raising, instead of providing incentives to the polluters (OECD, 1989). "The water pollution charge is felt to be rather inefficient in an economic sense but efficient in an administrative sense." (OECD, 1989, p7).

In the OECD investigation of the application of economic instruments, "the German water pollution charges is the only known effluent charge system in the field of water pollution with a clearly stated incentive purpose." Because the pollution control system is closely linked with regulation, it was hard to assess the effectiveness of effluent charges in isolation from regulation. But the research used the rapidly growing water technology market and technical innovation as an indicator to evaluate effectiveness.

In the assessment of the incentive impact of the charge systems (OECD, 1989), three variables were discerned: direct regulation, charges, and negotiations between authorities and firms on setting standards. The correlation shows that abatement has been influenced by charge levels. It was also concluded that charges had the largest contribution to the control of organic matter.

London Economics reports a study about the potential for using economic instruments as a means of air pollution control. The purpose was to provide "convincing theoretical and empirical analysis" (London Economics, 1992, p1) for a defensible rationale to use market mechanisms. The parameter in this study was SO_2 and the target group include the electricity industry, refineries and other industries emitting SO^2. The first part of the study "examines whether market mechanisms offer significantly less costly ways of achieving chosen air quality objectives", using economic principles to evaluate the efficiency of the market mechanisms.

Ong and Ngan (1991) reported in their study on environmental management in Malaysia that effluent charges have been used to control effluents from palm oil mills and rubber factories. The notable successes of using effluent charges are the resulting technology renovation and related research development. Although charges have been levied on manufacturing wastewater, for example, "a fee is charged for the licence at the rate of $100 per tonne of BOD discharged inland waters..." (p43), the control of discharges from manufacturing and sewage has been rather slow for a variety of reasons. The authors pointed out that this approach (a mix of regulation, permits and charges) "requires enormous manpower, a prolonged gestation period, and considerable immediate expenditure and does not permit immediate enforcement action which is urgently needed to contain the present load of pollution as well as to overcome the cumulative pollution problems due to rapid industrialisation and urbanisation." (Ong and Ngan, 1991, p50).

In conclusion, the previous studies and projects conducted in evaluating the effectiveness of economic instruments used technical innovation, or rapidly growing water technology market and technical innovation, or pollutants as either indicators or parameters. Some researchers realised that it was difficult to assess the effectiveness of effluent charges in isolation from other existing instruments, therefore, direct regulation, charges, and negotiations were used as variables to assess the incentive impact of charges.

The notable successes using effluent charges is the resulting technology renovation and related research development. The successful control of organic matter by using effluent charges was reported. However, the mix system of regulation, economic instruments and other instruments requires enormous manpower and considerable immediate expenditure. In addition, effluent charges require the determination of the sources of pollution, the total pollution load discharged, the assimilative capacity of the receiving water, and an accurate monitoring system.

3 Policy Context of Using Effluent Charges in China

ENVIRONMENTAL POLICY AND MANAGEMENT CONTEXT

The development of environmental policy in China can be divided into three stages, starting in the late 1970s. In the first stage, each piece of legislation would only address a certain environmental pollution problem in isolation, responding to and dealing with problems as they arose, with few provisions for determining indirect or long-term environmental impact. In 1980s, the comprehensive Environmental Protection Act provided the foundation for the development of different environmental laws such as the Water Pollution Control Act. A series of acceptable ambient or effluent quality standards of water were established. These characteristics reflect the increased understanding of the issues related to environmental pollution. Environmental protection was considered into the fundamental law system of the country. In the third stage, the Pollution Protection Act was issued and the Environmental Protection Act was amended by National People's Congress. Water Quality Guidelines are being developed by the National Environmental Protection Agency in consultation with many national departments, and with the provinces. Establishing comprehensive environmental policy has resulted in the improvement of the environmental situation. The difference between environment decision-makers is the degree to which they favour social versus economic solutions.

The water quality management system in China has also been developed along with policy development. Responsibilities for water used to be dispersed among ministries and among departments of the national government. For example, the Ministry of Agriculture, the Ministry of Forestry , the Marine Bureau, the Ministry of Chemical Industry and the Ministry of Energy Resources had administrative responsibilities for water management by establishing their own water protection department. The government's increasing concern with the dispersion of the power to protect water quality led it to create the The Environmental Protection Committee in 1986, intending to bring together most of the agencies with environmental responsibilities into one committee. Members of the committee are the representatives from other ministries with environmental responsibilities. Important issues are to be discussed and decided by the committee at its regular meetings. The Standing committee of the National People's Congress has given power to Environmental Protection Committee to establish special laws in environmental protection (National People's Congress has the supreme power to make the important laws, for example, the Environmental Protection Law of the People's Republic of China). The National Environmental Protection Bureau coordinates with other ministries responsible for development of economy and technology to implement and enforce environmental policy. Environmental monitoring stations, environmental research institutes, environmental training centres and information centres are the services directly under the administration of NEPB. It is reported that there are 2039 monitoring stations and 148 research institutes in the provinces and municipalities of the country (Environmental Year Book of China, 1991).

Each level of government has the legislative and regulatory authority over the environment, as well as an important leadership role in integrating the environment and the economy. In recent years, significant progress in monitoring and assessing water quality in rivers and lakes throughout China has been achieved by establishing formal national/provincial agreements, defining the responsibilities in collecting and analysing water quality data in the provinces.

EVOLUTION OF INSTRUMENTS

According to the statistics from the nation-wide survey of industrial resource in 1985, 98% of rivers in the country have been polluted from industrial wastewater discharges (CIPSO, 1990). The effects of wastewater discharge vary from fish kills , eutrophic condition, oxygen depletion and long-term ecologic system damage. Therefore, the status of industrial wastewater pollution abatement in China can best be described as emergent.

Because of the increasing concern about long-term health risks associated with inferior water quality, the goal of water quality management has to be accomplished through effective instruments. Before 1979, the only instrument used for implementing environmental policy was regulation, consistent with the whole political climate of the country. In addition, the more coercive instrument was needed at that time because of the lack of understanding of natural resources by the public. Issuing regulations, viewed as important events to the public in China before 1979, can have strong impacts on the behaviour of both the public and industries toward the environment.

The change of economic policy toward a market economy in China is the basis for selecting effluent charges in water quality management. More and more factories, firms, and enterprises that are national property have been long-term leased to private parties, which links the personal benefit to the prosperity of the industry and is a impetus of market economy. Effluent charges give industries choices to control the level of treatment of the wastewater. According Pal's (1989) statement of typology of instruments, three instruments used in China can be presented in a continuum by their different degrees of coercion, as illustrated in Figure 4.

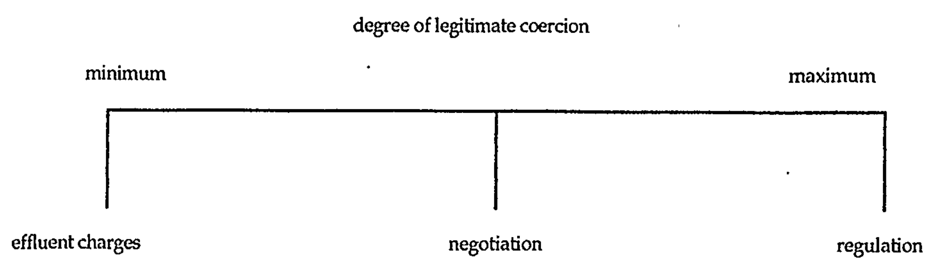

Figure 4: The Continuum of Coercion of Three Instruments

Source: Pal (1987), p37

From 1980 to 1990, the gross national product (GNP) of China has doubled resulting from the development of industry, yet the quality of environment has been maintained at the level of 1980, without further deteriorating (Chen, 1992). This indicates that environmental policy, the management system and the approaches used to implement and enforce the policy have developed significantly since the beginning of setting environmental policy and the management system. New approaches have been taken to enforce environmental policies, by going beyond the symptoms of pollution.

4 Methodology

Most industrial wastewater in China is from chemical, electric power, ferrous metal smelters, papermaking, coal mining, food, textile and mechanical industry. Typical pollutants from these industries are: suspended solids, biological oxygen demand, mercury, chromium, cadmium, arsenic, phenol, cyanide and petroleum (CIPSO, 1990). All eight types of industries mentioned above are found in Xingyu and those pollutants listed above are discovered in the Yuan River. Therefore, this case study conducted in Xingyu is typical and representative.

METHODOLOGY

Xingyu is a middle-sized city with about 35 factories. Key informant interviews were done in those 16 industries that discharge effluent into the Yuan River, the biggest river of the City. The correspondents are considered to be key informants because they all are engineers, managers, technicians or workers with knowledge of wastewater pollution control in their own factories. The first step was to develop a profile of the environmental status and environmental management of the City, the largest polluters in the City, a profile of main pollutants, and the flow rate from each factory, in order to choose appropriate pollutants as parameters to describe the behaviour changes from industries.

The second step is to determine if there are any problems occurring in the acceptability of effluent charges, the charge levels and enforcement from the regulatory agency, which result in negative behaviour changes.

The third step in the interview is to study each industry's response behaviour changes on pollution control from two aspects: first, activities in wastewater pollution control, including using new treatment technology or expanding and renovating existing facilities. Secondly, changes in effluent quality from each factory were examined by comparing effluent quality data before and after using effluent charges in 1987. The parameters to evaluate effluent quality improvement are the pollutants common to all sixteen factories (being able to compare the parameters among the factories) and pollutants with significant amounts discharged to the river. The methods used in this research included the historical method (records from documents), and the descriptive survey method, conducted by interviews.

SAMPLING DESIGN

The sampling design for collecting effluent quality data is based on the concept of key subjects sampling introduced in *Environmental Statistics* by Wu, Jingming (1991, p6). This sampling method is often used for industrial pollution surveys, selecting the major polluters as the population indicators. By studying these selected major polluters, the basic characteristics of the pollution situation can be understood. Of the 35 industries in Xingyu City, 16 industries discharge their wastewater directly to Yuan River. Therefore, these 16 factories are the study objects for the interviews.

Cyanate, biological oxygen demand and suspended solids were chosen as parameters to indicate effluent quality charges from different industries. Ten years of CN^-, BOD and SS discharge data from 1983 to 1992 were used for comparing effluent quality data before with after using effluent charges in 1987.

RESEARCH TOOL: THE QUESTIONNAIRE

The questionnaire (Appendix 1) was designed to fulfill the research objectives, including several parts: 1) profile of each factory, including the major product in the factories, the main pollutants discharged from factories, the amount of wastewater discharged to Yuan River from factories from 1983 to 1992, and the concentration of cyanate, biological oxygen demand and suspend solids in the effluent from 1983 to 1992; 2) problems causing negative response behaviours in pollution control from industries. Three causes are considered in this study: acceptability of effluent charges, charge levels, and the level of enforcement in implementing charges; and 3) response behaviour changes after applying effluent charges, involving the change in pollution control activities (such as using new treatment technology, expanding and renovating existing facilities), and the change in effluent quality after applying effluent charges in Xingyu in 1986, compared with the effluent quality before 1986.

PROCEDURES OF COLLECTING DATA

This section provides a detailed description of the exact steps taken to contact the research participants, obtain their cooperation, and administer the instruments; that is, when, where, and how the data were collected. Conducting the key informant interview included the following steps:

1. All the questions were pretested on a number of people to test whether there were any items difficult to understand or whether they clearly transferred the meaning the researcher is looking for;

2. Make phone contact or visit factories in order to discuss the qualification of key informants and to make appointments. To those who are not very often in their offices or hard to reach by telephone, the researcher sometimes had to go to their offices and wait there to make the appointments. All the key informants had been informed that participation in the interview was not mandatory and their names would not be disclosed, and that the researcher is a student in her thesis preparation. Those who did not want to participate were asked to give a reason. Only two said that during the interview time they would not be in town, but they recommended proper replacements;

3. In the interview, permission was asked to take notes. After compiling the data from the interview, the researcher checked the accuracy of the information, by contacting the participants again.

The four-month interview period was a multiple activity including meetings with the correspondents for interviewing and site visits (mostly the wastewater treatment facilities and process) after the interview. The first part of the interview (profile of the industry) was time-consuming, acquiring, checking and organising ten years' effluent quality data of each factory.

The second part, finding problems in the acceptability to effluent charges, charge levels, and enforcement from regulatory agency, was conducted with many discussions. The third part was a time-consuming process too because the correspondents had to recall the wastewater treatment development in the factories in the past ten years. Interviewing the official from Environmental Bureau of Xingyu was very rewarding because the correspondent answered the questions from a point of view based on conditions in the country and the city that the researcher might not have considered carefully.

The questionnaire did not include any sensitive questions about personal information. So the correspondents didn't hesitate while answering the questions. Acquiring the statistical data about effluent quality was not a difficult process, as part of them can be found in the compiled statistical data published by China Environmental Press each year. Through the process of talking to the professionals and managers, the researcher not only benefited from their working experience, but also was able to refine and improve the research scope, the strategy and the vision to view environmental protection in China. Those are the people who have been working very hard for environmental protection for many years.

5 Regulations, Effluent Charges and Negotiation

DIRECT REGULATIONS

Regulations can be of various types: discharge standards, ambient water quality standards, process and method of control specifications, and location limitations.
In China, the principal regulations in water quality control include the Environmental Protection Act, the Water Pollution Control Act, Surface Water Environmental Quality Standards, Wastewater Discharge Standards, and Fishery Water Quality Standards. In addition, there are guidelines, policy implementing methods, and an Act addendum, to explain the details of the basic acts or to supplement them in order to suit the needs of economic and social development.

The content of the regulation specified for effluent discharges from industries contains: 1) exact point of discharge to river, creek, lake or inlet, 2) maximum rate of discharge, based on the unit of product of each industry, for example, 60 m^3 of wastewater/tonne of paper for paper mill, 3) limits of the concentration of effluent which must not be exceeded, for example, the limit of suspended solids discharged to the first class of water body is 200 mg/l, biological oxygen demand 60 mg/l, and cyanate 0.5 mg/l, and 4) two classes of water bodies. The first class of water body is used as a drinking water resource, has famous scenery, is a fishery protection area or has special economic and culture value. The second class is used as a common industry water resource, an agriculture water resource, a harbour, or common scenery water.

Any accidental effluent spill could result in a fine or prosecution under Section 37 of the National Water Pollution Control Act according to the degree of the damage caused by the spill. Any discharge from industry which exceeds the specific effluent standards as to concentration or maximum flow rate may also be penalised under the Pollution Control Act. Industries and firms with ability to mitigate the pollution but not doing so, must be penalised with a 10,000 to 50,000 Yuan fine (equivalent to

$2000 to $10,000CND) depending on the pollution damage caused. The manager of the industry or the person who caused the damage must be prosecuted or penalised with disciplinary action.

It is obvious that the regulation mechanism has its limitation to control pollution to effective levels. Whether such inability is inherent in regulations or merely the result of inappropriate formulation and implementation is debatable. However, its drawbacks might be attributed to some features of the regulations. For example, an industry is either under or over the standards. Once the standard is met there is no incentive for further abatement. Furthermore, the regulatory agency has to seek compensation in court but the outcome is not always predictable (especially as to the level of the fine), which may result in a hesitancy to proceed against violators unless there is an obvious offence. The discontinuous nature of enforcement may result in a lack of incentive by corporations to meet standards entirely.

As a result, a situation could conceivably arise where a significant number of industries are exceeding standards. The actual seriousness of this situation would depend on the sensitivity of the environment to the waste discharged.

EFFLUENT CHARGES

The laws for implementing effluent charges contain: Collecting Effluent Charges Provisional Method, Provincial Collecting Effluent Charges Method, Adjusting Effluent Charge Levels to High-concentration Wastewater, and documents about the earmarking of the fees collected. The National Water Pollution Control Act states that all industries and firms discharging pollutants must pay effluent charges. The concentration of effluents in excess of effluent standards must reduce the degree of pollution after paying the charges. The Detailed Rules of the National Water Pollution Control Act states that those industries or firms, not paying charges according to rules, may be penalised by fines of 1000 to 10,000 Yuan (about $200 to $2000 CND) in addition to the charges and have to abate pollution, eliminate harm and compensate for damage.

Under the Provincial Collecting Effluent Charges Methods, the charges to those industries and firms not having met effluent standards will be raised by 5% each year progressively over three year. The charges must be paid within 20 days after billing day. An overdue fee of 0.1% of the charges per day is assessed. If the overdue period is more than two months, the industry or firm will receive warning from environmental regulatory and may have to pay 1000 to 10,000 Yuan in fines.

NEGOTIATION

Negotiations are likely to reduce perceived uncertainties, possibly on both sides of the bargaining table. Industry agreements are examples. Negotiation is often used in conjunction with regulatory or economic instruments. Opschoor and Vos (1989) in their OECD document state that negotiation internalises "environmental awareness and responsibility into individual decision-making by applying pressure and/or persuasion either indirectly or directly" (p21). In Xinyu City, negotiation often occurs in between industries and government conferences aimed at agreements on controlling specific pollutants, for example, on controlling heavy metals and phenol from industries.

Throughout the study, the policy tools used to meet the environmental goals employ a mixed mechanism. First, effluent charges in China are used for controlling pollutants discharged by industries. However, although polluters have "rights" to discharge wastes to water, these rights have been limited by regulations - effluent standards. Secondly, even though heavy metals can also be discharged to water bodies, monitoring of them is much more strict than for BOD or SS. The concentrations of those pollutants are not allowed to be discharged beyond the limits regulated in the standards because of the influence of negotiation. Therefore, the actual situation is: effluent charges are effective on 29 types of pollutants, including BOD, SS and heavy metals. But heavy metals and some pollutants affecting human health directly are strictly controlled and monitored by regulations, and reduced after the negotiation. For example, phenol is a major pollutant discharged from Xingyu Steelworks; in 1985 this problem was solved by building a secondary treatment facility, based on the result of negotiation.

6 Profile of the Study Area

GENERAL DESCRIPTION OF XINYU CITY

Population and Economic Structure

Xinyu is located at the northwest edge of Gan-Fu flatlands. The total area of the city is approximately 7143 km^2, with a length of 109.9 km from east to west and a width of 65 km from south to north. The population of Xinyu City was 913,401 in 1990, a substantial increase from the 1960s population before the industry framework was formed. Population density was 128/km^2, consisting of 21 ethnic groups, fairly evenly distributed in the city. Xinyu has been recorded as a county since A.D. 267. After 1960 it became a city because of the rapid increase in population. The economy of Xinyu City is primarily based on the iron and steel industry, because of the abundant iron ore mine. Xinyu is listed highest in output value and profit tax from iron and steel in Jiangxi province. Of the 75 middle cities in China, Xinyu City is one of the top five cities in China in terms of economic development and best economic profit (Xinyu City Annals, 1993).

By 1985 the economic structure of Xinyu was formed as a mixture of national, joint and privately-owned business. In 1985, there were 89 state-owned enterprises, 224 cooperations (state, private and combinations), 2269 private-sector partnerships and 2269 single-person enterprises. State enterprises accounted for 88.59%, others 11.41%, of the industrial output value of the City. Xinyu City is an important manufacturing base for iron and steel, chemicals, paper goods, textile products, casting and foundry materials, and agricultural commodities. Meat packing, once a major industry, has declined with only a few operations remaining. The location of the industries as subjects of the study is shown in Figure 5 and Figure 6. Electronic Equipment, Brewery, Paper Mill, Dye Works, Coal Mine, Coal Washing and Iron Ore Dressing are located in the upstream of Yuan River, about 95 km away from Xinyu. Eight other industries are in the middle and downstream.

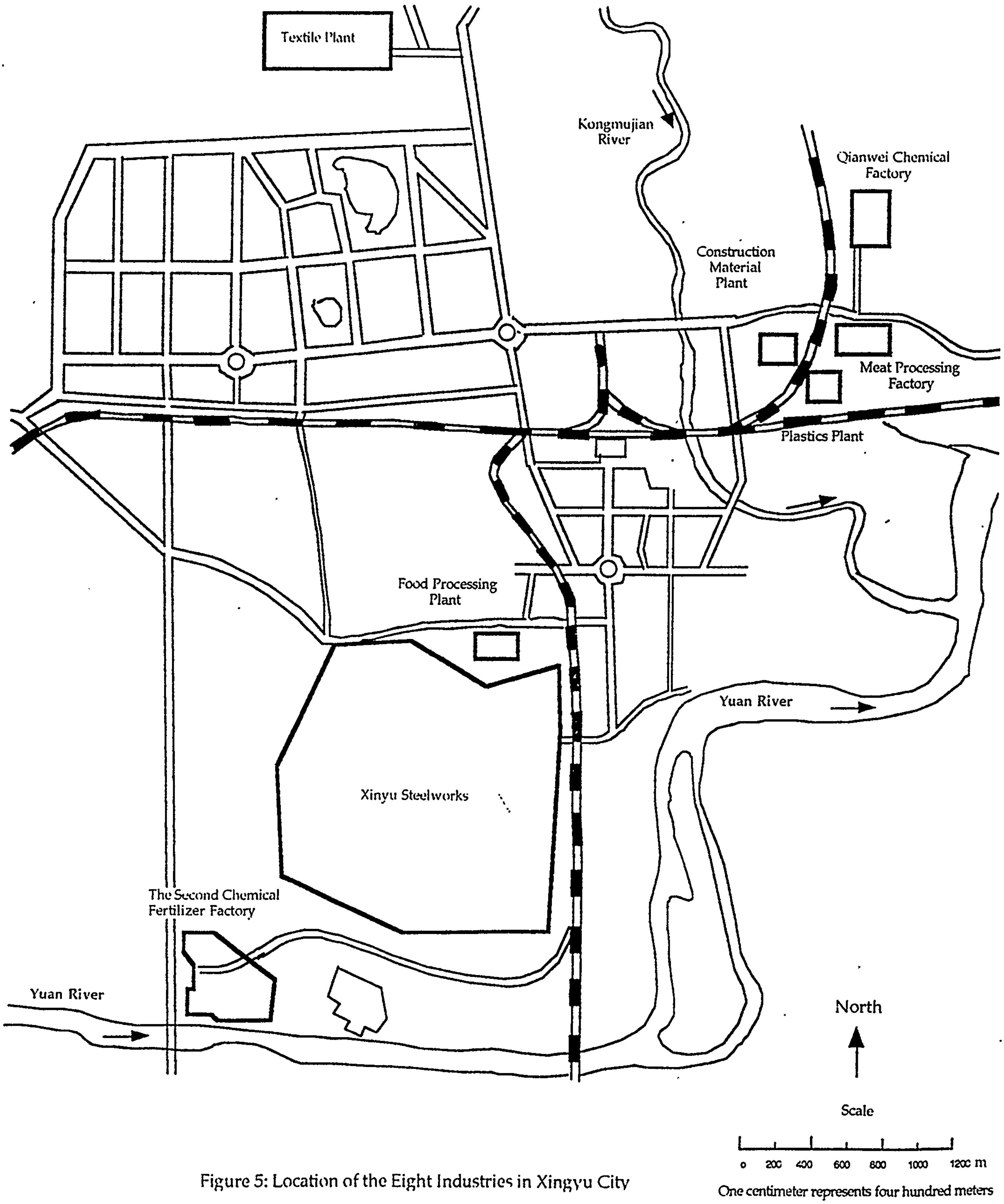

Figure 5: Location of the Eight Industries in Xingyu City

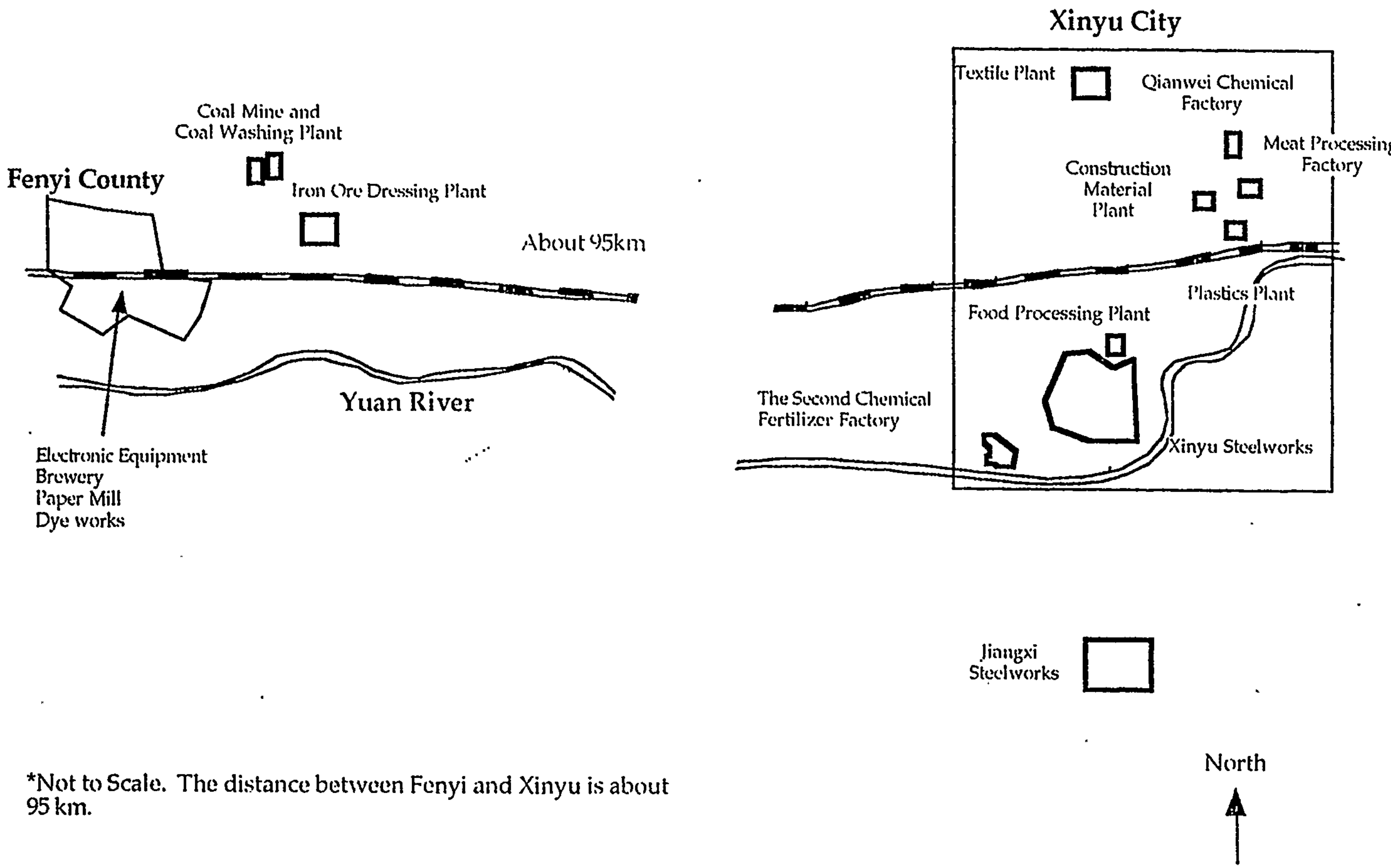

Figure 6: Distribution of the Sixteen Industries along Yuan River

Climate

The climate is typical of the subtropical zone, with fluctuations in both temperature and annual precipitation. Winters are fairly mild; summers are hot with humid conditions. Recorded temperatures at Xinyu City range from 40^{0}C to minus 7.2^{0}C. Mean temperature is 17.7^{0}C. Annual precipitation averages 1594.8 mm at Xinyu City. Rains are common in the spring from March to June. Climatic extremes that range from droughts to cloudburst-induced floods have been recorded. Annual evaporation capacity is 1497.5 mm average at Xingyu City. Average streamflow of Yuan River is 80.63 m^3/s. Streamflow in all of the major tributaries of the Yuan River is regulated by flood control or irrigation reservoirs. This regulation tends to reduce extreme variations in flow in the lower rivers. Runoff from uncontrolled minor tributaries following heavy rainfall can produce sudden increases in streamflow.

ENVIRONMENTAL STATUS OF XINYU CITY

In the 1950s, the Yuan River was described as "beauty of water" for its water being as clean as a "mirror". Yuan River water was used as drinking water by local people, carried from river to home directly. However, with more and more industries, such as smeltery, iron dressing, electric power, chemical engineering, textiles, being built along the river, quality of Yuan River water has deteriorated because of the vast amount of wastewater discharged to it directly.

The industrial pollution in China is calculated by "the ratio of equal-class industrial pollution", a concept based on the concentration of pollutants and the number of pollutants discharged*. The total ratio of equal-class pollution of a factory is the sum of the ratio of equal-class pollution of all the pollutants discharged from this factory. 90% plus of the ratio of equal-class industrial pollution is from Jiangxi and Xingyu Steelworks.

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* The formula to calculate the ratio of equal-class industrial pollution is: $Pi = C_i / |C_{oi}| * O_i * 10^{-6}$, where P_i = the ratio of equal-class pollution of certain pollutant (tonne/day or tonne/year), C_i = the concentration of certain pollutant (mg/l), $|C_{oi}|$ = the absolute value of industrial discharging standard of certain pollutant, Qi = wastewater amount containing certain pollutant (tonne/day or tonne/year).

ENVIRONMENTAL MANAGEMENT

Xinyu government has exercised a series of measures to mitigate this critical water pollution situation. The measures include environmental monitoring, environmental impact assessment, abatement time limit and environmental education. The legal and regulatory system in the City and the environmental management teams from industries have formed a framework to conduct the tasks of environmental protection with those measures. Implementation and enforcement of effluent charges has been undertaken by the same framework without very much extra administrative cost.

Environmental Monitoring

From 1981 to 1985 the Environmental Protection Bureau of Xinyu tested the water quality of the Yuan River in different locations. There was a quite large difference in the water quality among these locations. From the outfall of the Second Chemical Factory to Yuan River Bridge, the concentration of different pollutants was the highest. Two major tasks to the Environmental monitoring station related with water quality are: 1) Yuan River Water Quality Testing: every two months the monitoring station tests Yuan River quality at baseline location, control location and dilute location. The parameters are: PH, total SS, total hardness, dissolved oxygen, chemical oxygen demand, biological oxygen demand, ammonia, nitrite, nitrate, phenol, fluoride, cyanate, mercury, chromium, lead, oil, bacteria and colour. 2) Pollution sources monitoring: technicians regularly monitor the effluent quality from outlets of factories that are the main pollution sources.

Preventing New Pollution

Environmental impact assessment, started early in the 1980s, has been a key process in preventing new pollution. The Environmental Regulatory Agency prevents projects from proceeding without doing EIA reports. Projects must show that they do not have significant negative impact on the environmental quality.

Another new measure to prevent new pollution is the "polluter-responsible-for-treatment" regulation. Pollutant treatment devices must be designed, constructed, and operated along with the process of a development project. A project will receive permission to operate only after all pollution control devices have met the requirements set by the regulatory agencies. Based on this regulation, Xingyu Steelworks invested 8.73 million Yuan, 9.46% of the total investment of the project for building a 600 m^3 blast furnace. The new facility reused more than 90% of the wastewater.

Abatement Time Limit

The environmental regulatory agency has the power to order any industry violating environmental rules or standards to abate pollution within a time limit. For example, City government ordered Xingyu Steelworks and Jiangxi Steelworks to mitigate their pollution in certain production processes by a certain date in 1979. In 1985, 48 industrial projects considered as major pollution resources were ordered to establish or update their pollution control processes within the same year.

Environmental Education

Environmental education has been through broadcast, newspaper, post board, exhibition, seminar and magazine. Local government also organises training courses for environmental protection workers from each factory or firm. A worker graduated from the training courses would educate all the factory employees by holding seminars. After 1982 environmental education was listed as one of the necessary measures in the effective productivity of a factory. Jiangxi Steelworks used 2% of the its total bonus fund as environmental protection awards. In January of 1983, the City held an environmental protection commending conference. In 1985 the City's broadcasting and TV stations reported news about environmental protection and three seminars were held.

PROFILE OF INDUSTRIES

Table 1 lists the data of annual average wastewater flow, amount of CN^-, BOD and SS discharged from 1983 to 1992 from sixteen factories of Xinyu City to the Yuan River.

Table 1: Yearly Average Wastewater Flow, Amount of CN, BOD and SS Discharged from 1983-1992 from industries of Xinyu

Factory	Flow million tonne/year	CN tonne/year	BOD tonne/year	SS tonne/year
Xingyu Steelworks	329.84	232.88		7213.7
Jiangxi Steelworks	229.9	78.12		5125.09
Food Processing	0.11		2.96	6.13
Meet Processing	0.33		12.95	16.98
Qianwei Chemical	0.71	0.0036	61.38	30.24
Electronic Plant	0.029		1.05	1.55
Coal Washing	3.96		32.87	423.29
Second Chemical Factory	13.43	0.036	216.72	435.3
Coal Mine	3.31			249.74
Ore Dressing	7.78			425.29
Dye Works	0.034		1.18	0.83
Brewery	0.095		1.73	2.45
Construction Material	0.28			4.48
Paper Mill	0.55		6.05	73.22
Textile	5.68		41.19	94.68
Plastics	0.12		0.59	4.49
Total	596.16	311.04	378.67	14107.46

Annual Average Wastewater Flow

According to the data of annual average wastewater flow listed in Table 1 above, Figure 7 shows that the largest wastewater producers include Xinyu Steelworks, Jiangxi Steelworks and The Second Chemical Factory.

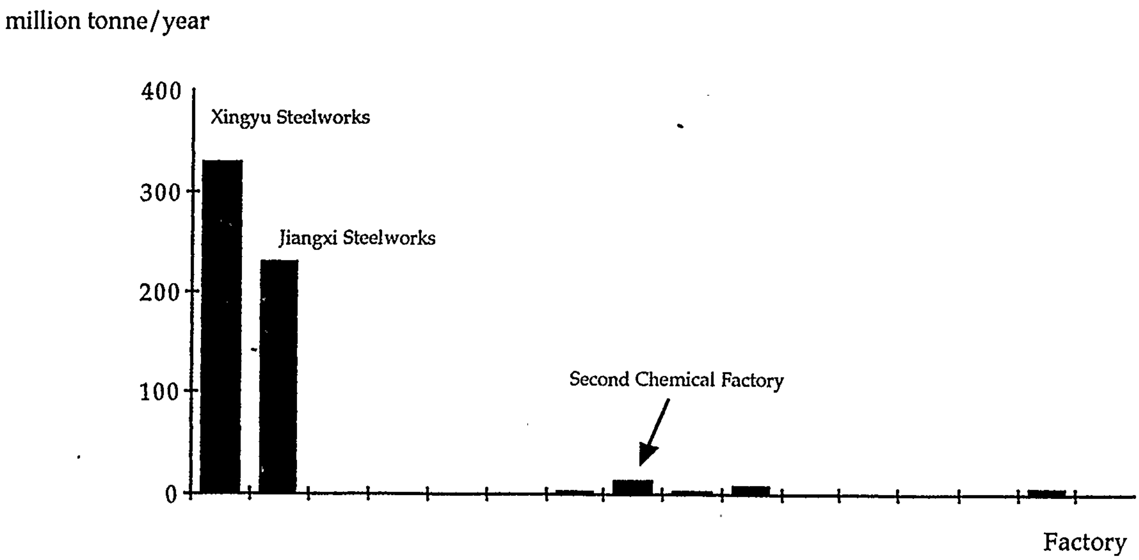


Figure 7: Average Amount of Wastewater Discharged to Yuan River Each Year from 1983 to 1992

Major Polluters of SS and BOD

Figures 8 and 9 show the average amount of SS and BOD discharged to the Yuan River over ten years (1983-1992) from each factory. The two steelworks are the most prominent SS producers. Coal Washing, The Second Chemical, and Iron Ore Dressing also the major SS producers in the study. Figure 9 shows that the Second Chemical, Qianwei Chemical, Textile and Coal Washing are the primary BOD producers.

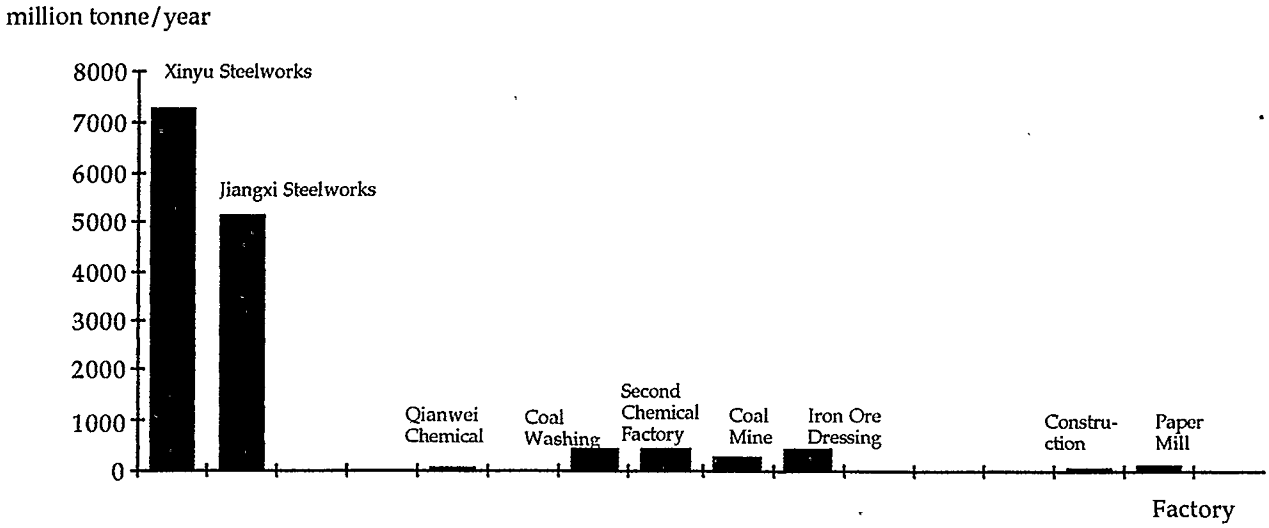


Figure 8: Average Amount of SS Discharged to Yuan River Each Year from 1983 to 1992

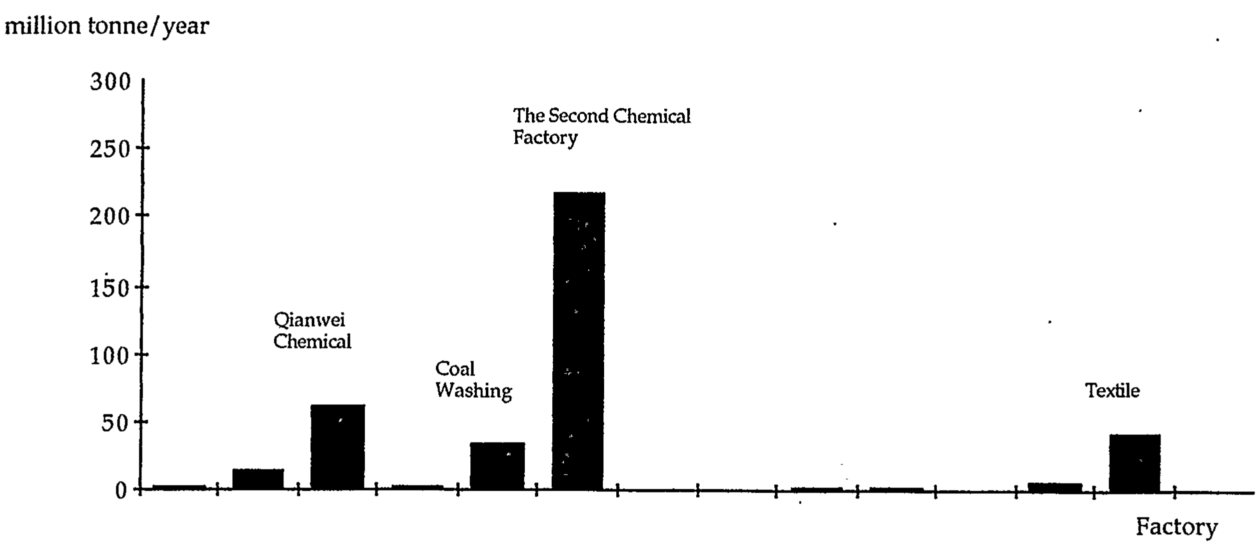


Figure 9: Average Amount of BOD Discharged to Yuan River Each Year from 1983 to 1992

Major Products and Main Pollutants

The main products and wastes from industries are listed in Table 2.

Table 2: Main Products and Main Pollutants

Factory	Main products	Main Pollutants
Construction Material Plant	Cement	SS
Paper Mill	Paper	BOD and SS
Plastics Plant	Phenolic plastics	BOD and SS
Xingyu Steelworks	Iron and steel	CN, phenol, oil and SS
Jiangxi Steelworks	Iron and steel	CN, phenol, oil and SS
Meat Processing Industry	Meet products	BOD, SS and bacteria
Iron Ore Dressing Plant	Iron ore	SS
Dye Works	Dye	BOD, SS and colour
Food Processing Company	Cake, preserved vegetables and cakes	nitrite, nitrate, BOD and SS
Qianwei Chemical Factory	Chemical solvent	CN, BOD and SS
Electric Equipment Factory	Electric instrument	Cd, Cr6+, BOD and SS
Brewery	Beer	BOD and SS
Coal Washing	Coal	BOD and SS
The Second Chemical Factory	Fertilizer	ammonia, BOD, SS
Coal Mine	Coal ore	SS, Hg, Cd, Pb
Textile Plant	Yarns	BOD and SS

The results from the questions about the profile of industries in Xinyu City are summarised as follows:

1. The pollutants discharged to Yuan River are: suspended solids, biological oxygen demand, ammonia, nitrite, nitrate, phenol, cyanate, mercury, chromium, lead, oil, bacteria, colour.
2. There is a large difference among the factories as to the yearly average flow rate from 1983 to 1992. The range is from 329.84 m^3/year to 0.034 m^3/year. The largest wastewater producers are Xinyu Steelworks and Jiangxi Steelworks.
3. Cyanate is a by-product only from four factories and the largest producers are Xinyu Steelworks and Jiangxi Steelworks.

4. The two steelworks are the largest SS producers. The amount of SS discharged from each was ten to twenty times higher than other large SS producers, which are: The Second Chemical, Iron Ore Dressing Plant and Coal Washing.

5. The four large BOD producers are: The Second Chemical, Qianwei Chemical, Textile, and Coal Washing.

7 Causes Resulting in Negative Behaviour Change

Some factors might cause negative polluters' behaviour change, such as a negative attitude toward effluent charges or low charge levels. Three factors that might cause negative behaviour change from industries were considered in this research: the attitude toward charges, the appropriateness of charge levels, and the enforcement of charges.

ATTITUDE TOWARD CHARGES: NECESSITY OF EFFLUENT CHARGES

"It is of crucial importance that target groups accept the economic instruments imposed upon them. Major resistance will render the instrument inefficient" (OECD, 1991). A positive attitude toward effluent charges is the first important condition for effluent charges to be conducted successfully. The attitude toward charges from respondents of the industries in Xinyu City was evaluated by asking an open question: "Do you think using effluent charges is necessary? Please explain the reason whether you think it is necessary or not." Figure 10 presents the data provided by the interviews to this question. Eleven correspondents, including three with positive attitudes but having difficulty paying the charges agreed that charge

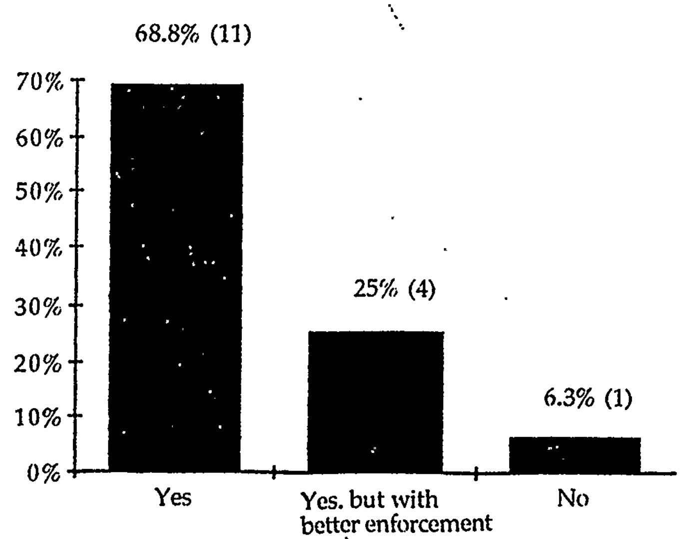


Figure 10. Response to the Necessity of Effluent Charges

levels are necessary for the protection of water quality. Four correspondents thought that charge levels are necessary if regulations were further reinforced. Only one factory gave a direct "no" answer.

Most of the industries appeared to have positive attitudes toward charge levels, including the major polluters. Good examples of these were three correspondents (Meat Processing, Iron Ore Dressing and Dye Works) who gave positive answers although their factories had difficulty paying charges because of competition in the market, deficit of the budget or in the stage of transition from planning economy to market economy. Four correspondents (Food processing, Qianwei Chemical, Electric Equipment and Brewery) argued that if the penalty was not enforced, the application of effluent charges would be meaningless. They still think that some industries did not pay the charges or pay the full price on time.

The explanation for the positive attitudes from the correspondents are:

1. Environmental education from media, government documents and training makes them aware that damage to water and its ecosystem from wastewater will affect the well-being of us and our future generations seriously.
2. Environmental protection is one of the responsibilities of industrial managers. Paying charges is mandatory.
3. Water quality hasn't been further deteriorated for some years. Charges play an important role in mitigating the damage caused by wastewater from industry to the river.

One correspondent (Textile Plant) thought that as long as the regulations have been enforced and effluent standards are not violated, the charges don't have to be paid. The correspondent did not think that using water as a public resource has to be paid for. This indicates that there are still some people who believe that water is a free resource.

APPROPRIATENESS OF CHARGE LEVELS

The second cause of negative behaviour change is the low charge level, which can result in a sub-optimal effect of changing behaviours. The question to examine the appropriateness of effluent charge level is: "Is the charge level too high, too low or appropriate? If it is not appropriate, in which way do you think it should be adjusted?" The results from sixteen correspondents were that ten correspondents thought the level is too low, three too high and three appropriate. Figure 11 shows the results.

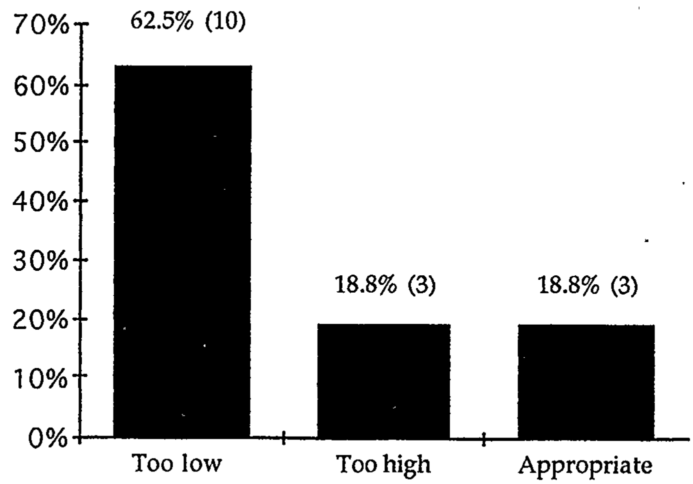


Figure 11: Response of the Appropriateness of Charge Levels

Most of the factories (62.5%) indicated that charge levels are too low. The three correspondents (18.8%) who thought charge levels are too high are those who had difficult paying the charges but believed that charge levels are necessary: Meat Processing , Ore Dressing Plant and Dye Works. Correspondents from Xinyu Steelworks, Jiangxi Steelworks and Construction Material Plant thought the charge levels are appropriate. The reasons for their responses are:

1. The two large steelworks have already taken responsibility for wastewater pollution control with well-equipped facilities, strong management and professional teams, and large investments; for example,

the concentrations of phenol in the effluents from these two steelworks meet the standards.

2. Because these two factories have had highest profit of productivity compared with other factories in the City, most of the subsidies (funding from the collection of effluent charges) for wastewater control were given to other industries. If the charge levels were higher, other factories would get more subsidies, which means that they just transfer their money to other factories.

The results of the appropriateness of charge levels suggests that most of the correspondents from middle and small industries in this city think that the charge levels are too low. Perhaps raising charge levels will not affect these factories too much because they can get compensation from subsidies. On the other hand, the relationship between occupation and response listed in Appendix 3 shows that all the correspondents who believe that the charge levels are too low are engineers working in the environmental field and factory managers, who are more aware of the water pollution crisis.

Suggestions for adjusting charge levels from correspondents are:

1. Simply adjust the charges to a higher level or to a lower level;
2. Only adjusting effluent charges levels is not enough. Further enforcement of effluent charges, for example, by penalty, is necessary.
3. The control of charge levels is based on effluent charge standards. This might cause a problem like dilution before discharge. One way around this is to control the total amount of waste from wastewater (concept of total-amount control).

ENFORCEMENT OF EFFLUENT CHARGES

Weak enforcement can result in ineffective use of effluent charges, as reflected in the negative response behaviour from polluters. Addressing this problem, an interview with a correspondent from the Environmental Protection Bureau was conducted in order to understand the process of implementing and enforcing effluent charges. The first question about enforcement and implementation of effluent charges is: What are the major factors preventing the implementation of charge levels?

The factors that mainly affected the enforcement of charges are:

1. Industry's ability to pay for the charges: In Xinyu, three factories have had difficulties paying the charges because of low profit. They were Meat Processing, Iron Ore Dressing, Dye Works.

2. Economic and political desirability of the project or industry. In 1983 Xinyu Steelworks and Jiangxi Steelworks withheld 80% of the charges they have paid as pollution subsidies in the factory. There was no noticeable action from the regulatory agency to this event.

3. The ambiguity of the rules to collect charges: In Methods of Collecting Effluent Charges in Jiangxi Province, the range of fines was too wide. For example, Item 21 stated that "the fine to those factories not paying charges on time is 0.1% of the charges per day. If the period of delaying payment is over two months, warning will be given by Environmental Protection Bureau and 1000 to 10000 Yuan may have to be paid." It was hard to control the level between 1000 and 10000 Yuan of fines.

4. Environmental Protection was just a department under the Minister of Rural and Urban Development and Environmental Protection. In recent years the Environmental Protection Bureau has moved from the periphery to the centre of decision making. But the position of EPB is still at the status of a junior ministry.

5. Limited funding.

The second question was how to enforce the penalties to those who violate the effluent charges. The answer was by penalties.

The third question to the correspondent from the regulatory agency was: is there any illegal dumping happening or more illegal dumping happening after the application of effluent charges? From the data collected from each monitoring station, illegal dumping was less than before, which is affected by several factors: First, through the education of environmental protection, the public and industrial managers realise that illegal dumping will cause deterioration of environment and many people have seen from the media the results of contaminated water. Secondly, the penalty for illegal dumping by industry is much more severe in recent years.

The last question was about the interval of monitoring the effluent from each industry. Generally, effluent from each industry is tested every two months. The effluent quality from major polluters is tested more often than those discharging little effluent. The data on effluent quality reported from each industry are verified at the laboratory from the monitoring station. The last question about enforcement was: do the industries pay their charges on time? The answer was that about half of the industries pay their charges on time.

8 Behaviour Changes by Industries in Response to Effluent Charges

Two response behaviour changes from industries to effluent charges were considered in this study, activities in wastewater treatment and the change of effluent quality after 1986, the year effluent charges started in Xinyu. The question to this part of the study was: After the application of effluent charges, what are the response behaviour changes on pollution control in your factory? The response behaviours include:

1. Improvement in wastewater pollution control activities, such as using secondary treatment or tertiary treatment, or expanding and renovating existing treatment facilities;
2. Reducing quantity or number of pollutants discharged.

CHANGES IN THE ACTIVITIES OF WASTEWATER POLLUTION CONTROL

The data in Table 3 show that wastewater control activities in the industries in Xingyu City can be divided into two stages: primary treatment facilities and process in the first stage; secondary treatment, tertiary treatment or chemical treatment (for example, contact oxidation, active carbon absorption, chlorination, chemical precipitation, and sludge digestion) in the second stage. Those factories which do not need secondary treatment for the wastewater have expanded and renovated their existing facilities, for example, the expanded facilities in Iron Ore Dressing Plant, and Electric Equipment Factory. There has been a rapidly developing environmental engineering market for technology, facilities and construction after 1987, the date of application of effluent charges.

Table 3: Stages of Activities in Wastewater Control

Factory	Stage one (before 1987)	Stage two (after 1987)
Xingyu Steelworks	screen oil removal sedimentation filtration flotation activated-sludge process	chlorination contact oxidation chemical precipitation sludge digestion
Jiangxi Steelworks	screen sedimentation oil removal filtration chemical precipitation activated-sludge process	chlorination flotation sludge digestion
Meat Processing Industry	screen sedimentation	chlorination contact oxidation sludge digestion
Iron Ore Dressing Plant	sedimentation	expanding and renovating the existing facilities
Dye Works	chemical precipitation	active carbon absorption
Food Processing Company	oil removal	screen
Qianwei Chemical Factory	chemical precipitation	filtration
Electric Equipment Factory	sedimentation	expanding and renovating the existing facilities

Brewery	screen sedimentation activated-sludge process	filtration sludge digestion
Coal Washing	sedimentation	expending and renovating the existing facilities
The Second Chemical Factory	chemical precipitation	expending and renovating the existing facilities
Coal Mine	sedimentation	expending and renovating the existing facilities
Textile Plant	screen trickling filtration sedimentation	chemical precipitation active carbon absorption
Construction Material Plant	screen sedimentation	expending and renovating the existing facilities
Paper Mill	screen sedimentation	flotation filtration
Plastics Plant	sedimentation	expending and renovating the existing facilities

However, problems have occurred with the introduction of new technology, equipment and facilities. For example, lack of experienced technicians, and equipment and facilities which were not durable enough, caused problems in maintenance and repair.

CHANGES IN INDUSTRIAL EFFLUENT QUALITY

The data on effluent quality from the sixteen factories from 1983 to 1992 was gathered and divided into two groups: one group was from 1983 to 1987 and the other was from 1988 to 1992. The first group of discharge quality data was when effluent charges were not applied before 1987. The second group of data was when regulations and effluent charges were applied at the same time to enhance each other. Negotiation has always existed in implementing water quality policy.

Trend of CN^- Concentration and Annual Total CN^-

Trend of CN- concentration

There are four factories discharging CN^- into the Yuan River. Table 4 shows that Qianwei Chemical and Second Chemical factories have controlled their discharges of CN^- to a very low concentration, compared with the permitted concentration in Wastewater Discharging Standards. Therefore, the interpretation focuses on Xinyu and Jiangxi Steelworks because the concentrations of CN^- from these two factories were higher than or close to the permitted CN^- concentration.

Table 4: Cyanate Concentration (mg/l), Sampling Time: June

Year	Xingyu Steelworks	Jiangxi Steelworks	Qianwei Chemical	Second Chemical	permitted concentration
1983	1.3	0.45	0.008	0.003	0.5
1984	1.1	0.67	0.007	0.004	0.5
1985	0.8	0.64	0.008	0.003	0.5
1986	0.9	0.35	0.006	0.002	0.5
1987	0.8	0.47	0.008	0.004	0.5
1988	0.7	0.24	0.007	0.003	0.5
1989	0.7	0.21	0.003	0.002	0.5
1990	0.8	0.12	0.004	0.001	0.5
1991	0.6	0.23	0.002	0.002	0.5
1992	0.8	0.14	0.003	0.002	0.5

Figure 12 shows that after the application of effluent charges, the concentration of CN^- from Jiangxi Steelworks has been controlled to under the permitted concentration (0.5 mg/l) with a continuing decline trend. After a large reduction in CN^- concentration from 1983 to 1985 (after the installation of a contact-oxidation process in the factory), the concentration of CN^- from Xinyu Steelworks was fairly constant, around 0.75 mg/l, which is still higher than the permitted concentration. This is because of a heavy production load. From the trends in cyanate concentration from 1983 to 1992 collected from each of the two steelworks, one can conclude that levying effluent charges had a positive impact on these two largest cyanate producers.

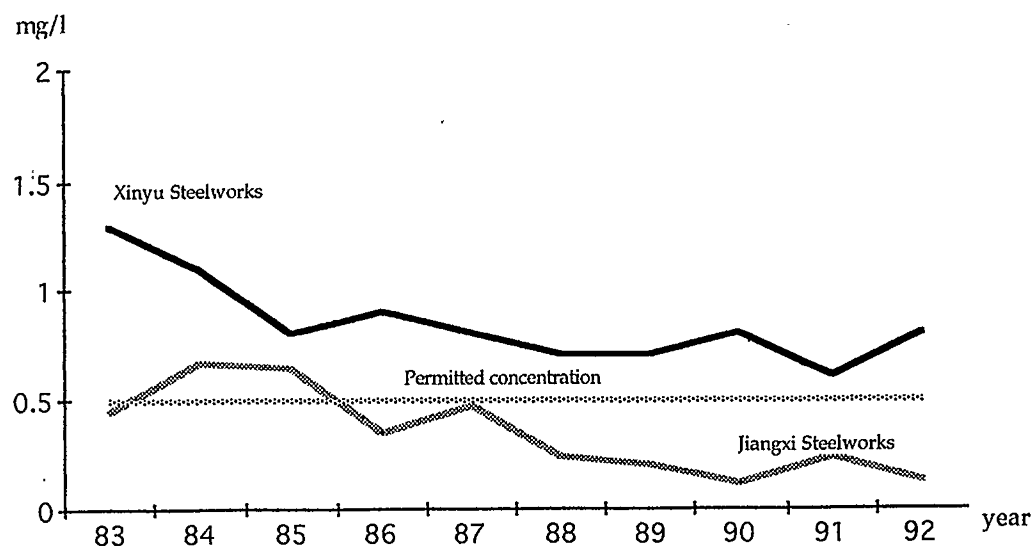


Figure 12: Trend of CN- Concentration of Two Steelworks

Trend of annual total CN^-

From the trend in concentrations of pollutants one will not get a correct conclusion if there is dilution of wastewater happening. It is important to look at each year's total discharged amount of CN^-. Table 5 shows the amount of CN^- discharged each from four factories in Xinyu. Because the amount of CN^- from Qianwei Chemical and Second Chemical are small, the focus is still on the two steelworks.

Table 5: Amount of Cyanate Discharged from Four Factories (tonne/year)

Year	Xinyu Steelworks	Jiangxi Steelworks	Qianwei Chemical	Second Chemical
1983	254.2	89.10	0.0034	0.037
1984	203.91	123.95	0.0022	0.052
1985	195.4	143.36	0.0052	0.045
1986	245.22	81.20	0.0038	0.042
1987	222.34	113.74	0.0057	0.072
1988	221.46	57.84	0.005	0.033
1989	240.1	50.40	0.0024	0.026
1990	265.16	30.48	0.0036	0.01
1991	229.92	60.03	0.0018	0.021
1992	250.94	31.08	0.0033	0.019

Figure 13 shows that the total discharged amount of CN^- from Xinyu Steelworks increased slowly, but that the one from Jiangxi Steelworks decreased dramatically. It should also be noted that the product output of Xinyu Steelworks almost doubled between 1983 and 1992, so discharge per unit of product decreased.

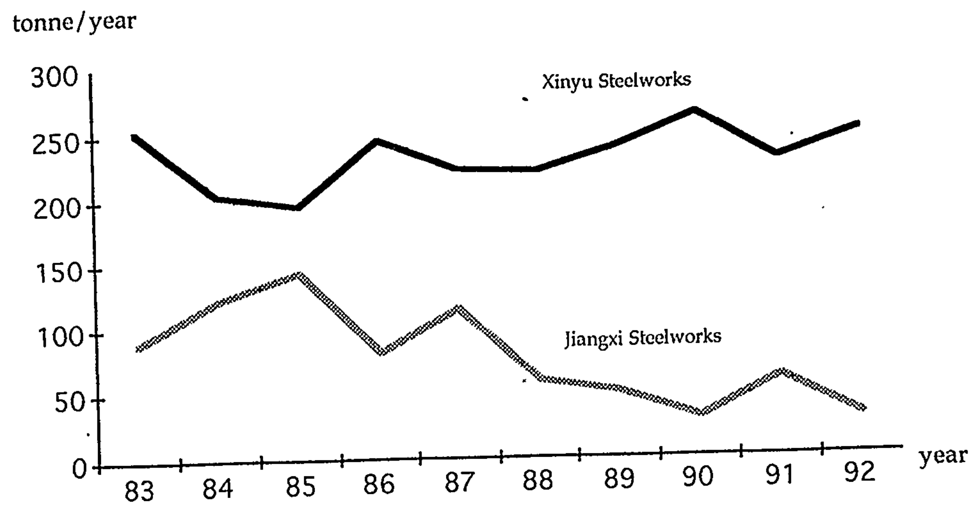


Figure 13: Annual Amount of CN^- Discharged from the Two Steelworks

There were three peaks of construction with urgent demand for iron and steel, in 1983, 1986 and 1992. The peak values (245.22 tonne/year and 250.94 tonne/year) reflect the demand peaks in productivity of Xingyu Steelworks.

It seems that the discharge of CN^- from Jiangxi Steelworks was strongly affected by effluent charges. Considering the increased productivity of Jiangxi Steelworks in recent years, maintaining the amount of CN^- discharged at a level similar to or slightly above that before 1983 means effluent charges did have an influence on control of CN- discharge in Jiangxi Steelworks.

Trend of SS Concentration and Annual Total SS

Trend of SS concentration

The Yuan River classifies in the second class of water body based on its function. Therefore, effluent concentration of SS that can be discharged into this type of water is 200 mg/l (SS concentration to the first class of water body is 70mg/l). Figures 14 to 19 show that all the factories have controlled their SS to under 200 mg/l since 1983 (the data are shown in Appendix 4).

The concentration of SS discharged was still much lower than 200 mg/l even in those factories with fluctuative concentrations of SS (Qianwei Chemical, Coal Mine, Food Processing, Electronic Equipment and Second Chemical). After 1987, eleven factories tended to discharge less and less SS into the Yuan River.

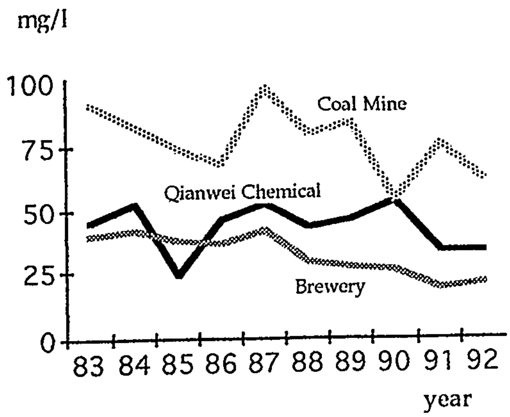
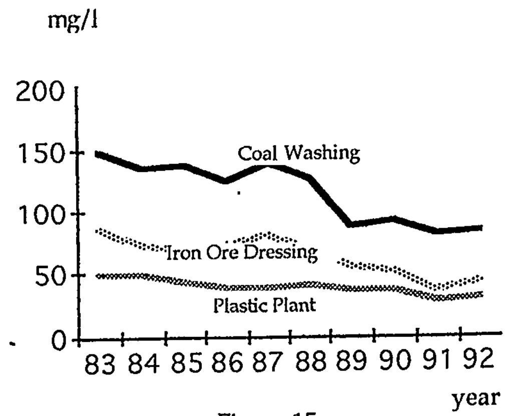


Figure 14



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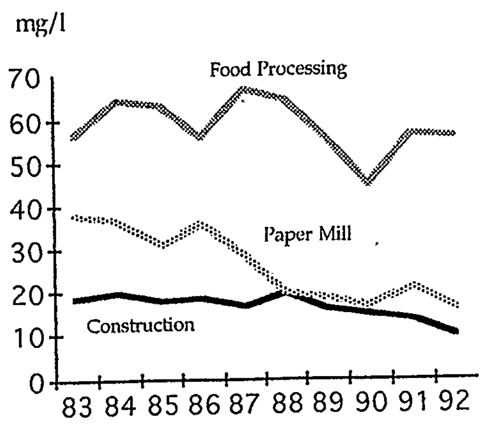

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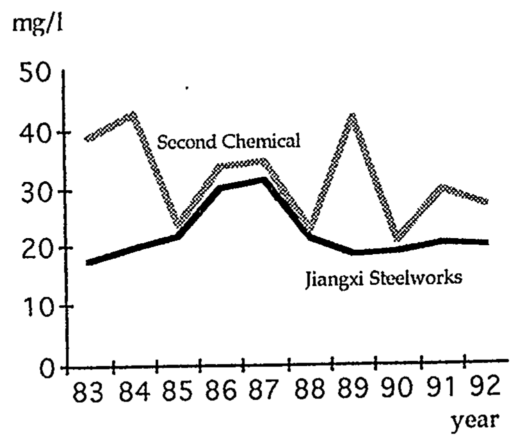

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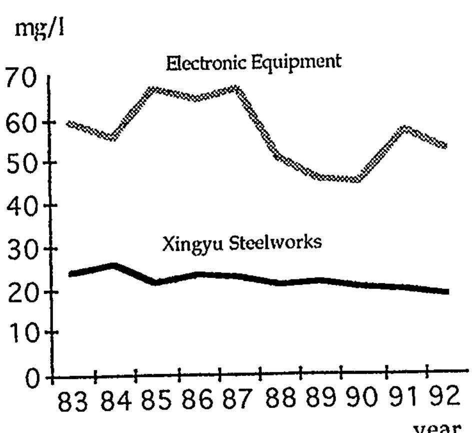

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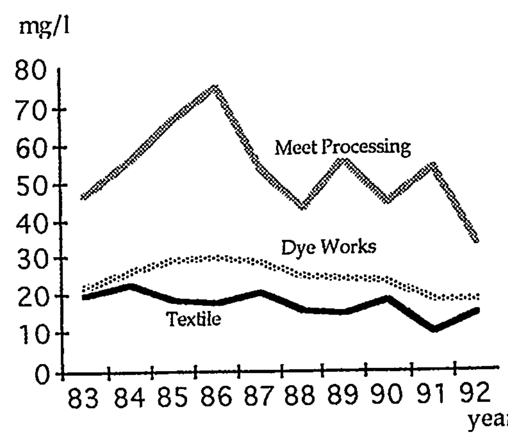
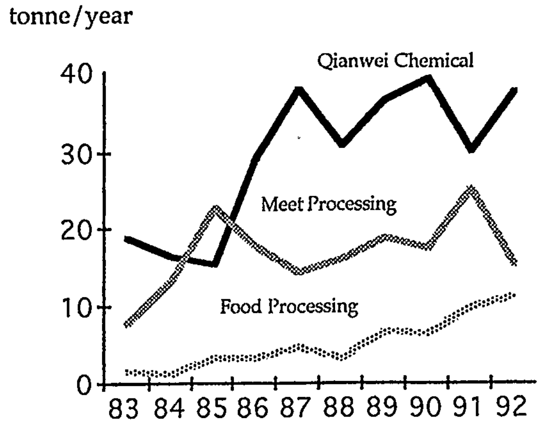


Figure 19

Figures 14 to 19: Trend of Concentration of SS from Sixteen Factories

Trend of annual total SS

Based on the data in Appendix 5, Figures 20 to 25 show that the growth rates of SS annual discharge from ten polluters have declined or the growth rate has become a reduction rate. Six other (Second Chemical Factory, Jiangxi Steelworks, Qianwei Chemical Factory, Meet Processing, Paper Mill and Food Processing) had large fluctuations and increase or decrease trend is not discernible. This overall result indicates substantial progress in controlling SS discharge.



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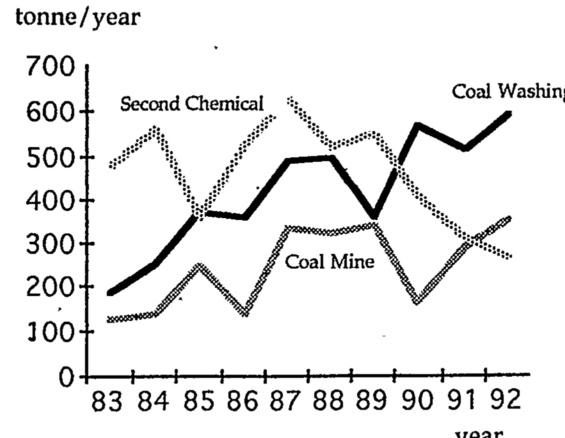

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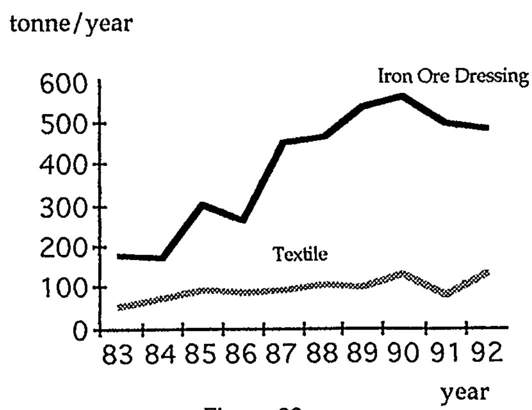

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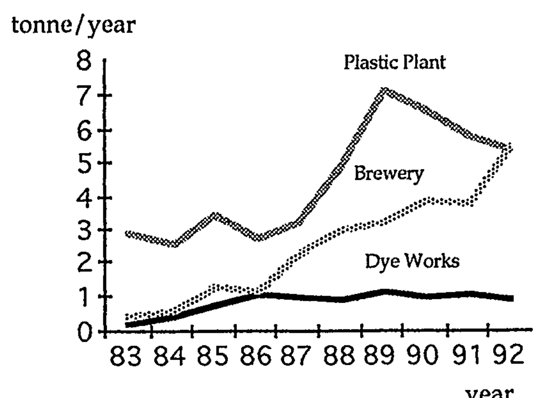

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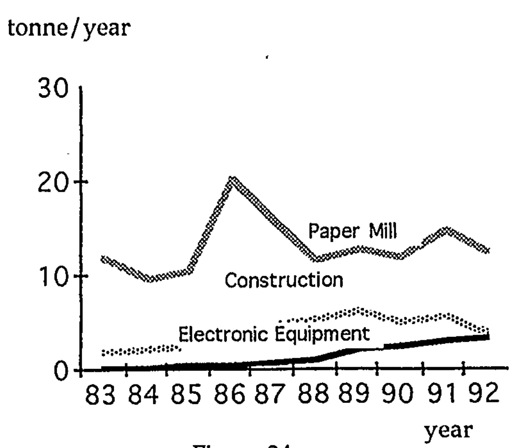

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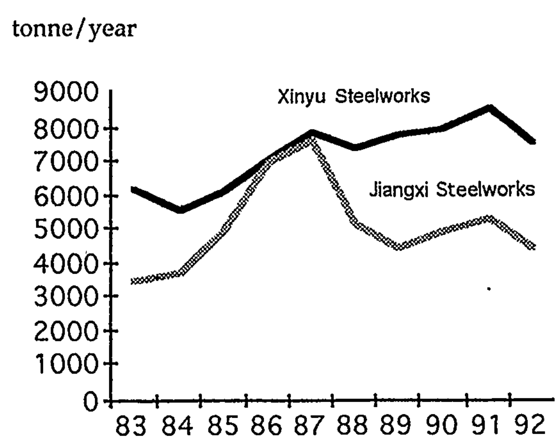


Figure 25

Figures 20 to 25: Trend of Total SS Discharges from Sixteen Factories

Because the amount of SS discharged each year from the major SS dischargers affects significantly the total amount of SS to Yuan River, it is necessary to examine the trend of annual SS discharge from the five largest SS producers, Xinyu Steelworks, Jiangxi Steelworks, Coal Washing, Second Chemical and Iron Ore Dressing, shown in Figures 26 and 27.

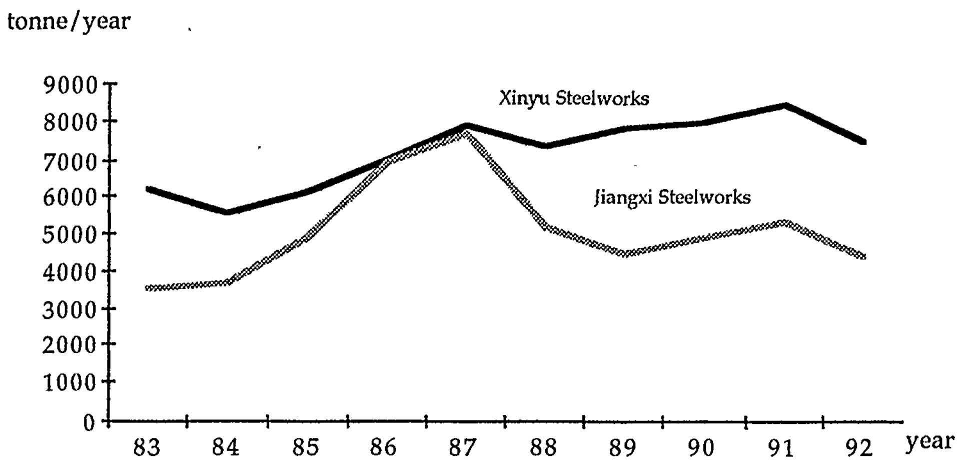


Figure 26: Trend of Total SS Discharges from Two Steelworks

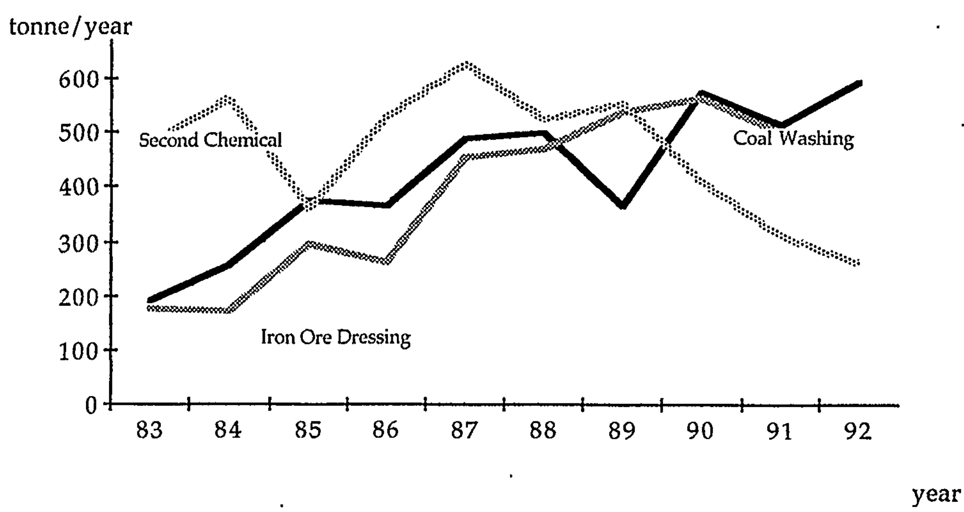


Figure 27: Trend of Total SS Discharges from the Other Three Major Producers

The increases in SS discharged have declined in Jiangxi Steelworks and Second Chemical in the period of applying effluent charges (i.e. since 1987). The increasing rates of discharged SS in Xinyu Steelworks, Coal Washing and Iron Ore Dressing were reduced after 1986. Therefore, the control of SS in Xingyu has been done very well both under the use of regulations from 1983 to 1986, and the combination of regulation and effluent charges from 1987 to 1992. The application of effluent charges has enhanced the control of discharged SS.

Trend of BOD Concentration and Annual Total BOD

In general effluent standards, the permitted concentration of BOD discharged from industry to a river is 60 mg/l. Special effluent standards have been issued for some industries producing very high concentration of BOD in their effluents. For example, the permitted concentration of BOD from Paper Mill is 180 mg/l, and from Brewery is 300 mg/l.

Trend of BOD concentration

Of the sixteen factories researched, eleven factories discharge BOD to Yuan River. Figures 28 to 31, based on the data in Appendix 6, demonstrate that from 1983 to 1986, only Dye Works and Electronic Equipment Factory discharged BOD with concentrations higher than 60 mg/l. Nine factories maintained their BOD concentration under 60 mg/l. After 1987 BOD concentrations discharged from each of these eleven factories has been under 60 mg/l. Therefore, BOD concentration in the effluent from industries had been controlled totally under the effluent standards limit after effluent charges were levied.

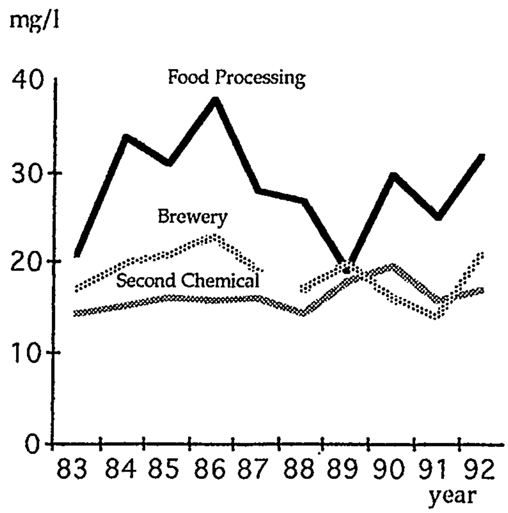
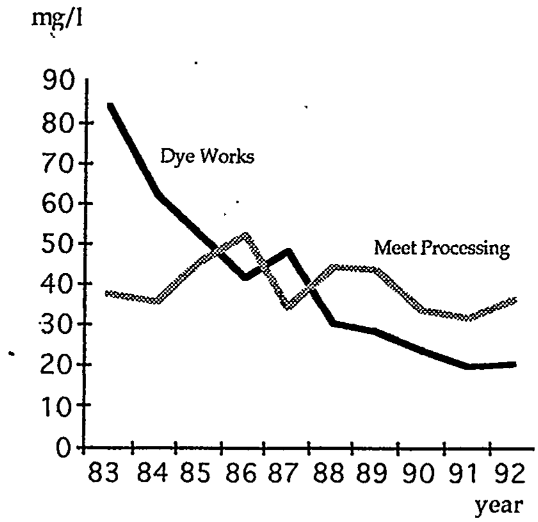


Figure 28



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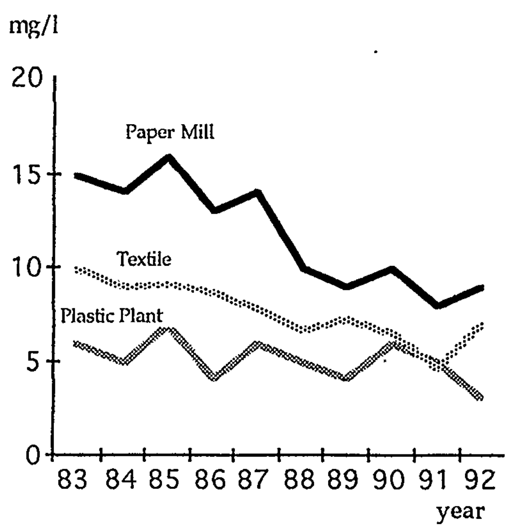

Figure 30

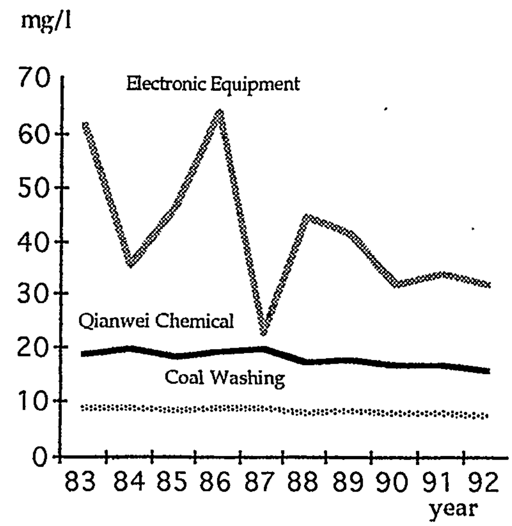

Figure 31

Figures 28 to 31: Concentration of BOD from Eleven Factories

Trend of annual total BOD

The above discussion shows that regulations had controlled BOD concentration under the limit of effluent standards. Figures 32 to 35 from the data in Appendix 7 show the trends in total BOD discharge.

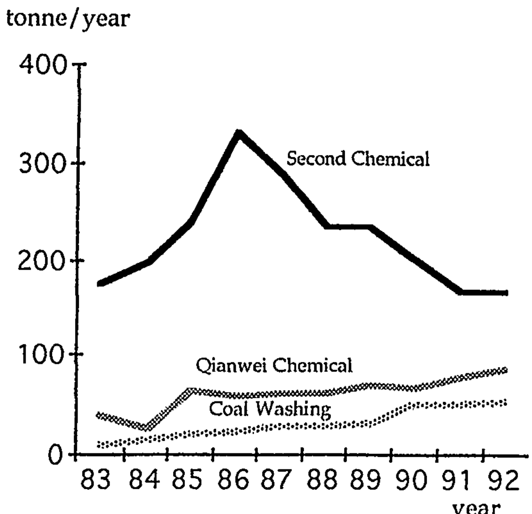

Figure 32

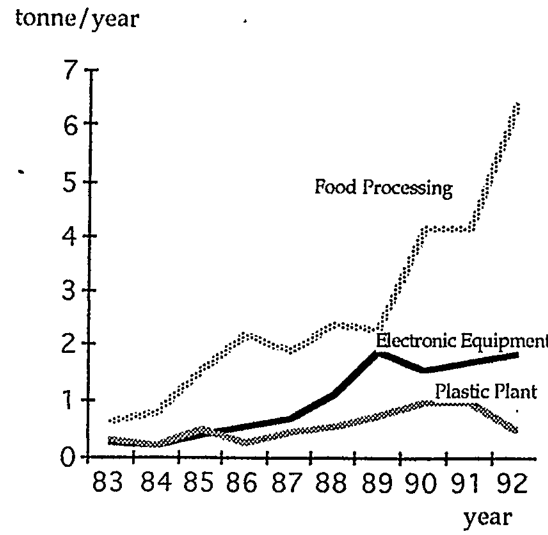

Figure 33

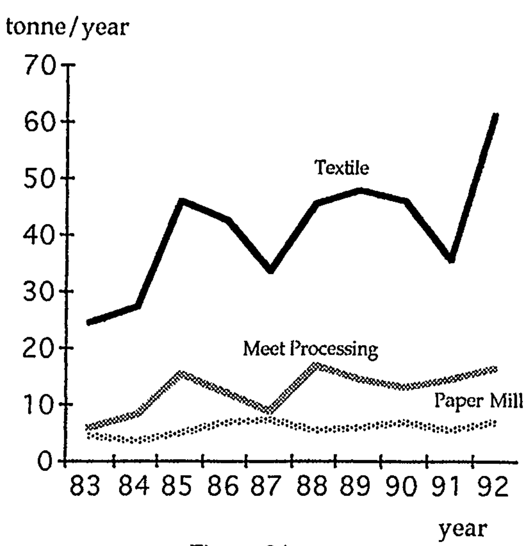

Figure 34

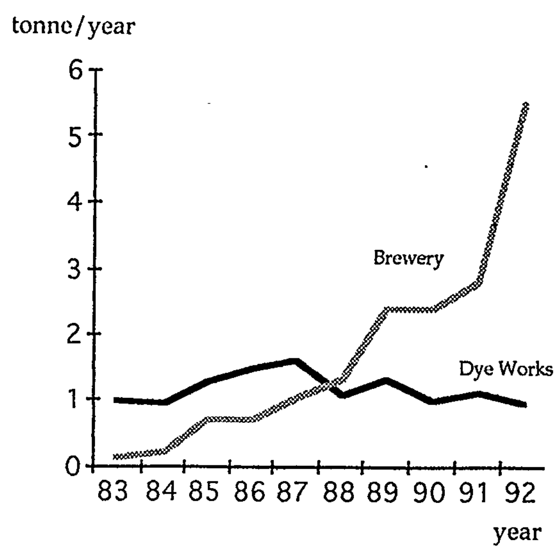

Figure 35

Figures 32 to 35: Total Annual BOD from Eleven Factories

There was a sharp reduction in total BOD discharged from Second Chemical Factory since 1986; Dye works decreased its total amount of BOD in 1988 and kept it at this level until 1992. Except for these two factories, all other factories had a overall tendency to increase their total amount of BOD discharge. Textile Plant decreased from 1986 to 1987, but its total amount of BOD increased again from 1987 to 1989, then dropped until 1991 when it again increased. That is, the total annual BOD discharge from Textile Plant was unstable, but there was an overall increase. Food Processing Factory and Brewery increased their BOD discharge progressively and rapidly. The other six factories also had progressive increases of BOD discharge, but not as rapid as Food Processing and Brewery.

Because Second Chemical Factory is the largest BOD polluter, the reduction of BOD from this factory is significant to the total amount of SS discharged in the City. However, statistically, decrease in total BOD discharge from only two out of eleven factories does not strongly support the application of effluent charges. Although the total annual BOD had decreased because of the BOD reduction from The Second Chemical Factory, the response behaviours from the majority of the sixteen factories were not positive.

In conclusion, the overall pattern of BOD discharge before and after the application of effluent charges has been highly variable without a clear trend. The fluctuation of BOD discharge is attributable to several factors, such as technical problems and economic growth.

9 Conclusions and Recommendations

CONCLUSIONS

Analysis of the data, interviews and effluent quality of sixteen industries presented and interpreted in previous chapters leads to the following conclusions:

1. Three instruments commonly used in China for implementing water quality policies are: regulations, effluent charges and negotiation.

2. The factors frustrating policy implementation are: 1) industry's ability to pay for the charges, 2) economic and political desirability of the project or industry, 3) ambiguity in law-making, 4) limited funding and 5) peripheral status in government decision-making.

3. Implementation and enforcement of effluent charges has been undertaken by the same framework without too much extra administrative cost.

4. Effluent charges are considered to most of the industries and have been accepted by most of them as a means to control effluent quality.

5. More than half (62.5%) of the correspondents believed that charge levels were too low.

6. About half of the industries pay their charges on time.

7. Less illegal dumping happened after the application of effluent charges.

8. After levying effluent charges, there was new development of wastewater treatment technology, and the expansion or renovation of existing facilities. There were problems: too few technicians, and undurable equipment and facilities, which caused unnecessarily high maintenance and repair cost.

9. Levying effluent charges had positive impacts on the two largest cyanate producers to reduce their concentrations and yearly CN^- discharge in effluent.

10. Regulations had controlled the discharge of SS gradually to below the effluent standards limits. The application of effluent charges has enhanced the control of SS discharge both in concentration and total annual amount.

11. The response behaviours of controlling BOD from the majority of the sixteen factories were not positive after levying effluent charges on them.

In conclusion, the success of applying effluent charges is in the aspects of acceptability, manageable administration and fund-raising in the industry in Xinyu City. Improvement of effluent quality had been achieved with respect to cyanate and SS, but not to BOD. The charge system is considered to be only partly effective because of low charge rates. The development and rapid growth of the water technology market might also indicate that the charge system has made at least some contribution to technical innovation. This effectiveness is the result of applying effluent charges, direct regulation and negotiation. The implementation and the enforcement depend not only on laws and regulations, but also on the use of social pressure and moral suasion.

RECOMMENDATIONS

1. Moderate increase in charge level is recommended.

Charge level may be expected to be effective only if their rates are sufficiently high, showing the economic significance. However, high effluent charge levels are based on detailed monitoring and complex management. This will considerably decrease the administrative efficiency and consequently, the economic efficiency of effluent charges. Low charges are not effective but overly high charges could encourage evasive behaviour and illegal dumping. Thus, moderate increase in effluent charge level is recommended.

2. It might be more appropriate to use site-specific effluent standards instead of across-the-board standards as the controlling threshold value.

Effluent charges have adopted across-the-board effluent standards as the controlling threshold value. But this type of standard does not consider the assimilative capacity of the river into which the wastewater is discharged. Thus, depending on the particular location, harmful pollution may or may not occur. It will be more effective to study the assimilative capacity around large factories which are major pollution sources. This study should not require an excessive effort in relation to the magnitude of investment in large factories, and the extent of possible environmental damage from wastewater discharged. Site-specific standards take account of the assimilative capacity of the local environment. If the optimum quantity and concentration of discharges can be specified, the most economic solution to the pollution problem can be achieved.

3. It might be effective to set different levels on the concentration of discharges from industries.

Quality of effluent from new or proposed industries has to meet the most stringent level; all existing industries should meet the second most stringent level. Eventually, when feasible in terms of the available technology, all existing discharge control should be upgraded to an appropriate level.

5. Using assimilative capacity to control the location of discharges and the location of industries can reduce costs.

A plant might be permitted to discharge its wastewater to a stream where there is unused assimilative capacity. It is one of the examples using natural treatment capacity of waste and is less expensive than abatement of waste in man-made facilities.

6. In the future, pragmatic approaches to new economic instruments should: 1) raise revenues for financing environmental projects, 2) provide incentives to change polluters behaviours, and 3) have a positive impact on technical innovation.

The tendency toward policy integration might influence the development of new, broad-based economic instruments.

7. In further studies of this type, it would be useful to relate effluent quantities to the productivity of the plant, ie. quantity of effluent to quantity of product.

References

Bartlett, R.V. (Ed.), (1989), *Policy through Impact Assessment: Institutionalised Analysis as a Policy Strategy*, New York, Greenwood Press.

Barton, B.J., Franson, R.T., and Thompson, A.R., (1984), *a Contract Model for Pollution Control*, Vancouver, the University of British Columbia.

Berdie, D.R., Anderson, J.F. and Niebuhr, M.A.; (1986), *Questionnaires: Design and Use*, London, the Scarecrow Press, Inc..

Bower, Blair T., Barre, Remi, Kuhner, Jochen,and Russell, Clifford S., (1985), *Incentives in Water Quality Management: France and the Ruhr Area*, Washington, Resources for the Future Inc..

Brown, M. Paul, 1992, *Organizational Design as Policy Instrument: Environmental Canada in the Canadian Bureaucracy*, inRobert Boardman, (Ed.) Canadian Environmental Policy: Ecosystems, Politics, and Process, Oxford, Oxford University Press.

Caldwell, L.K., (1990), *International Environmental Policy, Duke Press Policy Studies*, Durham (U.S.A.), Duke University Press.

CEDR Committee,(1992), *China Environment and Development Report*, Beijing, China Environmental Science Press.

Chen, Y., (1992), *National Report of the people's republic of China on Environment and Development*, Beijing, China Environmental Science Press.

China Environmental Yearbook Committee, China Environmental Yearbook, China Environmental Science Press, Beijing, China, 1991

CIPSO (China Industry Pollution Survey Office), Evaluation and Research on National Industrial Pollution Sources, China Environmental Science Press, Beijing, China, 1990

China National Environmental Protection Agency, (1992), *Environmental Management Regulations and System in China*, Beijing, China Environmental Science Press.

China National Environmental Protection Agency, (1992), *Environmental Protection of Township Industries in China*, Beijing, China Environmental Science Press.

China National Environmental Protection Agency, (1992), *Environmental Education in China*, Beijing, China Environmental Science Press.

Committee for Economic Development, Research and Policy Committee, (1993), *What Price Clean Air? - a Market Approach to Energy and Environmental Policy*, New York, Committee for Economic Development.

Corfee-Morlot, J., and Jones, T., (1992), *Designing a Practical Tax System for Greenhouse Gas Emission Abatement: an Introduction*, OECD (Ed.), Climate Change -- Designing a Practical Tax System, Organization for Economic Co-operation and Development, Paris, OECD.

Derman, William, (1990), *Informant Interviewing in International Social Impact Assessment*, in Kurt Finsterbusch, Jasper Ingersoll, & Lynn Liewellyn (Eds.), Methods for Social Analysis in Developing Countries, San Francisco, Westview Press.

Dewees, D.N., (1978), *Analysis of Water Quality Management Policies: a Case Study of the Thames River, Institute for Environmental Studies*, Toronto, University of Toronto.

Doern, G. Bruce, (1991), *Canadian Environmental Policy*, C.D. Toronto, Howe Institute.

Doern, G. Bruce and Phidd, Richard W., (1981), *Canadian Public Policy: Ideeas, Structure, Process*, Methuen.

Dorcey, A.H.J.,(1976), *the Uncertain Future of the Lower Fraser*, Vancouver, Westwater research Centre, University of British Columbia.

Dorcey, Anthony H.J., (1977), *Policy Mechanisms for Water Quality Management in a Metropolitan Area: Greater Vancouver and the Fraser Estuary*, in Stephenson, James B. (Ed.), the Practical Application of Economic Incentives to the Control of Pollution, Vancouver, University of British Columbia Press.

Dorcey, A.H.J., (1991), *Perspectives on Sustainable Development in Water Management: Towards Agreement in the Fraser River Basin*, Vancouver, Westwater Research Centre, University of British Columbia.

Environmental Canada, (1987), *Federal Water Policy*, Ottawa.

Fenton, B.A., (1989), *the Canadian Water Resources Equipment Industry: Opportunities for Research and Manufacturing*, Ottawa, Science Council of Canada.

Disher, Anthony C., (1981), *Resource and Environmental Economics*, Cambridge, Cambridge University Press.

Fox, Irving K., (1977), *the Assessment of Pollution Control Policy Mechanisms: Some Basic Concepts*, in Stephenson, James B. (Ed.), the Practical Application of Economic Incentives to the Control of Pollution, Vancouver, University of British Columbia Press.

Fox, Irving K. et al, (1970), *Institutional Design for Water Quality Management: a Case Study of the Wisconsin River Basin*, Madison, Wisconsin, University of Wisconsin Water Resources Centre.

Hague, Paul, (1993), *Questionnaire Design*, London, Kogan Page Limited.

Hammer, E.R., (1977), *Environmental Policy: a Sociological Assessment of Abatement Alternatives*, Pennsylvania, the Pennsylvania State University.

Harriet I., Rueggeberg & Andrew R. Thompson, (1984), *Water Law and Policy Issues in Canada*, Vancouver, Westwater, Uinversity of British Columbia.

Hellawell, J. M., (1986), *Biological Indicators of Freshwater Pollution and Environmental Management*, London, Elsevier Applied Science Publishers.

Hu, B.L., Chao, D.Y. and Yong, Y.H., (1991), *Theory of Environmental Act*, Beijing, Press of University of Politics and Law.

Ingersoll, Thomas G., and Brockbank, Bradley R.,(1986), *the Role of Economic Incentives in Environmental Policy*, in Sheldon Kamieniecki, Robert O'Brien, and Michael Clarke, (Eds), Controversies in Environmental Policy, New York, State University of New York Press.

Inquiry on Federal Water Policy, (1985), *Currents of Change: Final Report*, Ottawa.

Interdepartmental Committee on Water, (1990), *Federal Water Policy: a Progress Report*, Ottawa, Government of Canada.

Jenkins, Robin R. (1993), the Economics of Solid Waste Reduction, Aldershort (England), Elgar.

Kelman, S., (1983), *Economic Incentives and Environmental Policy: Politics, Ideology, and Philosophy*, Cambridge, the MIT Press.

Lajzerowicz, Joseph, Reilly-Roe, Peter, (1977), *Technology and Economics of alternative Control Mechanisms*, in James B. Stephenson (ed), The Practical Application of Economic Incentives to the Control of Pollution: the Case of British

Columbia, Vancouver, University of British Columbia Press.
Lester, J.P., (1989), *Environmental Politics and Policy: Theories and Evidence*, Durham, Duke University Press.

London Economics, (1992), *the Potential Role of Market Mechanisms in the Control of Acid Rain*, Department of the Environment Environmental Economics Research Series, London, HMSO.

Meyer Resources, Inc. (1990), *Economic Measures for Integrating the Environment and the Economy in British Columbia*, Victoria, Round Table.

Nicolaisen, Jon and Hoeller, Peter, (1990), *OECD Department of Economics and Statistics Working Papers*, Paris, Organisation for Economic Co-operation and Development.

Organisation for Economic Co-operation and Development, (1993), *Taxation and the Environment - Complementary Policies*, Paris, OECD.

Organisation for Economic Co-operation and Development, (1991), *Environmental Policy: How to Apply Economic Instruments*, Paris, OECD.

Organisation for Economic Co-operation and Development, (1976), *Study on Economic and Policy Instruments for Water Management - Water Management in Canada*, Paris, OECD.

Ong, Augusting S.H., Maheswaran, A., and Ngan, Ma Ah, (1991), *Environmental Management in Southeast Asia - Direction & Current Status*, Singgapore, Faculty of Science, National University of Singgapore.

Opschoor, J.B., and Vos, Hans B. (1989), *Economic Instruments for Environmental Protection*, Paris, Organisation for Economic Co-operation and Development.

Pal, L.A., (1987), *Public Policy Analysis*, Toronto, Methuen Ltd..

Panem, S. (Ed.), (1983), *Public Policy, Science, and Environmental Risk*,Washington, the Brooking Institution.

Peskin, H.M. and Seskin, E.P. (Eds), (1975), *Cost Benefit Analysis and Water Pollution Policy*, Washington, the Urban Institute.

Petak, W.J., (1980), *Environmental Planning and Management: the Need for an Integrative Perspective*, Environmental Management, 4, No. 4, 287-295.

Platek, R., Pierre-Pierre, F.K., & Stevens, P., (1985), *Development and Design of Survey Questionnaires*, Ottawa, Statistics Canada.

Pollution Management Department, China Environmental Protection Bureau, (1991), *Water Environmental Management,* Beijing, China Environmental Science Press.

Qu, D.M., (1990), *Environmental Acts,* Beijing, China Environmental Science Press.

Qu, G.P., (1991), *Environmental Issues and Strategies of China,* Beijing, China Environmental Science Press.

Qu, G.P. and Li, J.C., (1990), *China Population and Environment,* Beijing, China Environmental Science Press.

Repetto, R. (1990), *Promoting Environmentally Sound Economic Progress: What the North Can Do,* Washinton, World Resources Institute.

Roque, C.R., (1990), *Factors Influencing Environmental Policies in Developing Countries,* Manila, Science Research Foundation, University of the Philippines.

Rueggeberg, H.I. and Thompson, A.R., (1984), *Water Law and Policy Issues in Canada,* Vancouver, Westwater Research Centre, the University of British Columbia.

Ruitenbeek, H. Jack, (1991), *Towards New Fundamentals - Indicators of Ecologically Sustainable Development,* Ottawa, Canadian Environmental Advisory Council.

Sandbach, F., (1980), *Environment Ideology and Policy,* Allanheld, Osmun Publishers.

Seneca, Joseph J. and Taussig, Michael K., (1974), *Environmental Economics,* New Jersey, Prentice-Hall, Inc..

Simonis, Udo Ernst, (1991), *Beyond Growth - Elements of Sustainable Development,* Berlin, Edition Sigma.

Stahl, H.L., (1977), *Environmental Policy and Welfare Economics,* Cambridge, Cambridge University Press.

Stephenson, J. B., (1977), *the Practical Application of Economic Incentives to the Control of Pollution: the Case of British Columbia,* Vancouver, University of British Columbia Press

Swartzman, Daniel, Liroff, Richard A and Croke, Kevin G. (1982), *Cost-Benefit Analysis and Environmental Regulations: Politics, Ethics, and Methods,* Ottawa, The Conservation Foundation.

Tang, Y.T. and Liu, R.H., (1990), *Introduction of Environmental Management,* Beijing, Environmental Science Press.

Tchobanoglous, G., (1979), *Wastewater Engineering: Treatment/Disposal/Reuse,* New York, McGraw-Hill Book Company.

Tietenberg, Thomas H, (1994), *Economics and Environmental Policy,* Brookfield, Elgar.

United Nations, (1976), *Principles and Methods for the Provision of Economic Incentives in Water Supply and Waste Water Disposal Systems,* a Report Prepared Under the Auspices of the ECE Committee on Water Problems, United Nations.

Vogel, D., (1986), *National Styles of Regulation,* London, Gorness University Press.

Xia, G., (1992), *Environmental Pollution and Economic System,* Beijing, China Environmental Science Press.

Editorial Board of Xinyu City Annals, (1993), Xinyu City Annals, Hangzhou, Wanli Publishing.

Appendix 1: Questionnaire

Profile of the Factory:
1. What is the major product in your factory?
2. What is the main pollutants discharged from your factory?
3. Please list the amount of wastewater discharged to Yuan river from your factory from 1983 to 1992?
4. Please list the concentration of cyanate, biological oxygen demand and suspend solids in the effluent from 1983 to 1992?

Acceptability of Effluent Charges and Charge Levels
5. Do you think using effluent charges is necessary? Please explain the reason whether you think it is necessary or not
6. Is the charge level too high, too low or appropriate? If it is not appropriate, in which way you think it should be readjusted?

Enforcement of Implementing Effluent charges
7. What are the major factors preventing the implementation of charge levels?
8. How do you reinforce the penalty to those whose violate the effluent charges?
9. Is there any illegal dumping happened or more illegal dumping happened after the application of effluent charges?
10. How often do you monitor the effluent from each industry?
11. Do the industries pay their charges on time?

Response Behaviours to Effluent Charges: Activities in Pollution Control and Effluent Quality Changes

12. After the application of effluent charges, what are the response behaviour changes in activities on pollution control in your factory? The response behaviours include:

(1) choosing other wastewater treatment alternatives besides primary treatment, such as secondary treatment or tertiary treatment;
(2) expanding and renovating existing treatment facilities;
(3) reducing quantity or number of pollutants discharged;

Appendix 2: Participants' Occupation

OCCUPATION OF CORRESPONDENTS

Factory	Manager	Engineer	Technician
Construction Material Plant	X		
Paper Mill		X	
Plastics Plant		X	
Xingyu Steelworks		X	
Jiangxi Steelworks		X	
Meat Processing Industry			X
Iron Ore Dressing Plant	X		
Dye Works	X		
Food Processing Company		X	
Qiangwei Chemical Factory		X	
Electric Equipment Factory		X	
Brewery		X	
Coal Washing		X	
The Second Chemical Factory		X	
Coal Mine		X	
Textile Plant		X	
Total	3	12	1

Appendix 3: Occupation vs. Charge Level

CORRESPONDENTS WITH DIFFERENT OCCUPATION

Factory	Too low	Too high	Appropriate
Xingyu Steelworks			X (engineer)
Jiangxi Steelworks			X (engineer)
Food Processing Company	X (engineer)		
Meat Processing Industry		X (technician)	
Qiangwei Chemical Factory	X (engineer)		
Electric Equipment Factory	X (engineer)		
Coal Washing	X (manager)		
The Second Chemical Factory	X (manager)		
Coal Mine	X (worker)		
Iron Ore Dressing Plant		X (manager)	
Dye Works		X (manager)	
Brewery	X (engineer)		
Construction Material Plant			X (manager)
Paper Mill	X (manager)		
Textile Plant	X (engineer)		
Plastics Plant	X (manager)		

Appendix 4: Data of SS Concentration

SS CONCENTRATION (mg/l), SAMPLING TIME: JUNE

Year	Qianwei Chemical	Meet Processing	Brewery	Plastic Plant	Coal Washing	Coal Mine	Iron Ore Dressing	Food processing
1983	45	47	40	49	149	92	86	57
1984	53	56	42	51	136	83	75	65
1985	24	67	38	43	139	74	70	64
1986	46	75	37	39	127	68	73	56
1987	53	54	42	40	142	97	82	67
1988	43	43	30	41	129	80	69	65
1989	46	56	27	38	89	84	56	56
1990	54	45	26	37	94	54	53	45
1991	34	54	19	29	82	76	38	57
1992	34	34	21	30	85	62	43	56

Year	Electronic Equipment	Cons-truction	Textile	Paper Mill	**Jiangxi** Steelworks	Dye **Works**	Xinyu **Steelworks**	Second Chemical
1983	60	19	20	38	17.8	22.5	24.5	39
1984	56	20	23	37	20.2	26.7	25.8	43
1985	67	18	19	31	22.1	29.4	21.5	24
1986	65	19	18	36	30.1	30.1	23.7	34
1987	67	17	21	29	31.7	28.5	22.6	35
1988	51	20	16	20	21.6	25.3	20.9	23
1989	46	16	15	19	18.6	24.2	21.7	42
1990	45	15	19	17	19.3	23.9	20.2	21
1991	57	14	10	21	20.5	19	19.6	30
1992	53	10	15	16	20.1	18.5	18.7	27

Appendix 5: Data of Annual Average Amount of SS

ANNUAL AVERAGE AMOUNT OF SS (tonne/year)

Year	Qianwei Chemical	Meet Processing	Brewery	Plastic Plant	Coal Washing	Coal Mine	Iron Ore Dressing	Food processing
1983	18.9	7.8	0.4	2.94	193	128	181	1.71
1984	16.43	13.4	0.55	2.55	258	141	173	1.49
1985	15.6	22.8	1.3	3.44	375	252	301	3.2
1986	28.98	18	1.1	2.73	364	143	263	3.25
1987	37.89	14.3	2.3	3.2	492	336	456	4.7
1988	30.96	16.3	3	4.92	499	328	469	3.1
1989	36.8	19	3.2	7.22	365	346	542	6.72
1990	39.14	17.6	3.9	6.66	573	167	567	6.3
1991	30.26	25.4	3.8	5.8	517	296	499	9.7
1992	37.4	15.3	5.5	5.4	595	359	486	11.2

Year	Electronic Equipment	Cons-truction	Textile	Paper Mill	Jiangxi Steelworks	Dye Works	Xinyu Steelworks	Second Chemical
1983	0.3	1.7	50	11.8	3524.4	0.27	6227.9	479.7
1984	0.39	2	71.3	9.6	3737	0.4	5589.2	563.3
1985	0.6	2.2	95	10.5	4950.4	0.71	6140	360
1986	0.59	4.8	88.2	20.5	6983.2	1.05	7075.8	531
1987	0.87	4.6	90.7	15.9	7671.4	0.94	7894.2	630
1988	1.2	5.2	108.5	11.6	5205.6	0.89	7374.5	523
1989	2.1	6.1	98.7	12.7	4464	1.11	7810.6	554.4
1990	2.2	4.9	134.9	11.9	4902.2	0.97	7962.6	412
1991	2.9	5.6	76	14.9	5350.5	1.06	8497.6	315
1992	3.1	3.8	133.5	12.6	4462.2	0.85	7565.4	267.3

Appendix 6: Data of BOD Concentration

BOD CONCENTRATION (mg/l), SAMPLING TIME: JUNE

Year	Qianwei Chemical	Meet Processing	Brewery	Plastic Plant	Coal Washing	Food processing	Dye Works	Second Chemical
1983	19.3	38	17	6	9.2	21	84	14.3
1984	20.1	36	20	5	9	34	63	15.1
1985	18.5	46	21	7	8.7	31	53	16.1
1986	19.8	53	23	4	8.9	38	42	15.8
1987	20.1	35	19	6	9.1	28	49	16.2
1988	17.4	45	17	5	8.3	27	31	14.2
1989	18.1	44	20	4	8.5	19	29	17.9
1990	16.9	34	16	6	8.3	30	24	19.6
1991	17.3	32	14	5	7.9	25	20	15.9
1992	16.3	37	21	3	7.4	32	21	16.9

Year	Electronic Equipment	Textile	Paper Mill
1983	62	10	15
1984	36	9	14
1985	47	9.2	16
1986	64	8.7	13
1987	23	7.8	14
1988	45	6.7	10
1989	42	7.3	9
1990	32	6.5	10
1991	34	4.7	8
1992	32	6.9	9

Appendix 7: Data of Annual Average Amount of BOD

ANNUAL AVERAGE AMOUNT OF BOD (tonne/year)

Year	Qianwei Chemical	Meet Processing	Brewery	Plastic Plant	Coal Washing	Food processing	Dye Works	Second Chemical
1983	40.32	6.3	0.17	0.36	11.9	0.63	1.01	175.9
1984	27.59	8.6	0.26	0.25	17.1	0.78	0.945	197.8
1985	63.05	15.6	0.71	0.56	23.5	1.6	1.27	241.5
1986	59.85	12.7	0.71	0.28	25.5	2.2	1.47	331.8
1987	60.78	9.2	1.05	0.48	31.5	1.9	1.62	291.6
1988	61.2	17.1	1.34	0.6	32.1	2.4	1.09	236.3
1989	69.6	14.9	2.4	0.76	34.9	2.3	1.33	236.3
1990	66.43	13.3	2.4	1.01	50.6	4.2	0.98	201.9
1991	79.21	15	2.8	1	49.8	4.2	1.12	166.9
1992	85.8	16.7	5.5	0.54	51.8	6.4	0.97	167.3

Year	Electronic Equipment	Textile	Paper Mill
1983	0.31	25	4.7
1984	0.25	27.9	3.6
1985	0.42	46	5.4
1986	0.58	42.6	7.4
1987	0.71	33.7	7.7
1988	1.13	45.4	5.8
1989	1.93	48	6
1990	1.57	46.2	7
1991	1.73	35.7	5.7
1992	1.86	61.4	7.1