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Integrated Management of Industrial and Municipal Wastewater in China - Demonstration Project in Jiaxing, Zhejiang Province

Executive Summary

Part 1 of Final Report

Norwegian Institute for Water Research

REPORT

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Abstract

The city of Jiaxing in Zhejiang Province is a medium-size, rapidly expanding Chinese city located in a flat landscape with numerous canals. These are used for navigation, fishing, aquaculture and as drinking water source, but also as recipients for wastewater and runoff from agriculture, paved roads and solid waste landfills in the area. The canals are severely polluted. NIVA has been assisting Jiaxing Environmental Protection Bureau (JEPB) in finding solutions to the local wastewater problems. Several measures facilitate the transport of sewage to the nearby Hangzhou Bay, and sewage treatment processes before final disposal have been identified. The project has identified current and future wastewater production and recipient status. Based on pilot-plant operation and computer models a complete system for sewage collection and treatment has been suggested. This is based on transport of untreated sewage to Hangzhou Bay where the construction of a sewage treatment plant is planned. The treatment methodology is based on a flexible chemically enhanced primary treatment (CEPT), followed by a biological step at a later stage. The industry in the area discharges substantial quantities of potentially toxic wastewater to the sewer systems. There are, however, good possibilities for cleaner production routines in various factories. The project findings put emphasis on knowledge transfer and strengthening of JEPB resources to find solutions to the water-related problems in the city. In addition a detailed abatement plan should be developed, taking existing water quality, user interests and future water quality objectives into account.

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Part 1 of Final Report

NORAD project CHN 020

Preface

The city of Jiaxing in the Zhejiang Province is a medium-size rapidly expanding Chinese city located between Shanghai and Hangzhou. The city is situated on the lowlands South of Yangtze River, with numerous canals, which are influenced by tidal variations in the Hangzhou Bay to the Southwest. The canals are used for a multiple of functions, the main being drinking water, extensive barge traffic (transport), fishing and aquaculture.

The canals are also the recipients of untreated domestic as well as partly treated, but mostly untreated industrial wastewater. Runoff from agriculture, paved roads and solid waste landfills in the area also ends up in the canals. The canals are as a result of this multitude of activities, and are heavily polluted with a water quality far away from predetermined goals. Jiaxing is part of the Taihu lake influence area designated for special and highly prioritised clean-up activities by the government in Beijing.

During the last 3,5 years NIVA has had the pleasure to work with Jiaxing Environmental Protection Bureau (JEPB) on a NORAD-financed project, to assist JEPB in finding solutions to the wastewater treatment problems in the region. Special emphasis has been put on the potential and practical possibilities of integrating industrial and domestic effluents before treatment.

The project has identified several measures to help **transporting** the sewage to the nearby ocean, and has identified processes to **treat** the sewage before disposal into the Hangzhou Bay. We believe the project has been instrumental in changing the city's plans from local/de-centralised treatment to regional treatment. The project has also put emphasis on institutional strengthening and knowledge transfer, in addition to technical assistance and purchase of modern equipment to JEPB. We feel confident that the work carried out during these 3,5 years has been an important contribution to the plans for reducing the water-related pollution problems in the Jiaxing region. The project results are implemented and integrated in the city's overall plans for water-pollution abatement measures.

This project, which has been one of NIVA's first large involvements in the Peoples Republic of China, has given the Norwegian participants a unique insight in the rich and fascinating Chinese culture. I take this opportunity to thank all partners and contributors involved for their dedicated efforts. A special thanks goes to the office staff at JEPB which has always been outstandingly helpful, open for discussions, and enthusiastic in bringing the project forward. Last, but not least we – the Chinese and the Norwegians - appreciate the opportunity given us by Norad to carry out this, in many ways, pioneer-project.

Oslo, 23. June 2000

Finn Medbø

Contents

1. Introduction

This executive summary presents the main working procedures and the key findings and achievements from the project "Integrated Management of Industrial and Municipal Wastewater in China - Demonstration Project in Jiaxing, Zhejiang Province." The Norwegian Agency for Development Cooperation (NORAD) has funded the project. The project period has been from late 1996 to mid-2000. The project has been carried out in close co-operation between Jiaxing Environmental Protection Bureau, JEPB and The Norwegian Institute for Water Research (NIVA).

Important components of this wastewater management project include analysis and evaluation of the current and future pollution load, technical systems for collection and transport of sewage, suitable methods for sewage treatment and the condition of the receiving canals. The project has also focused on management systems, and a sketch of a master plan for wastewater management based on Norwegian practice is presented. JEPB has been provided upgraded analytical instruments, advanced computer tools and office equipment.

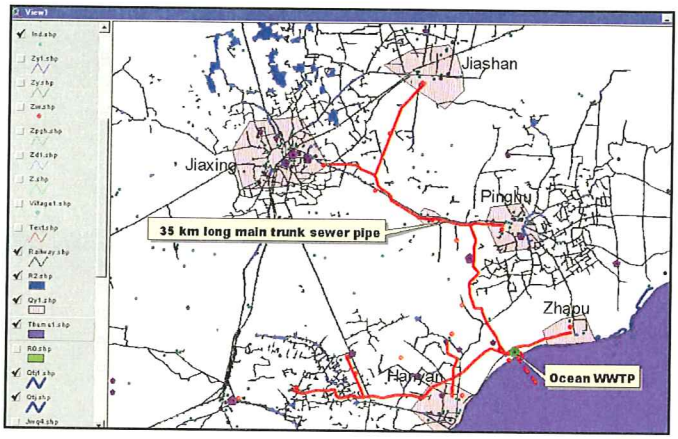
This executive summary represents the first part of the final report from the project, consisting of a total of 13 sub-projects. The second part of the final report shows additional documentation about the project background, results, assumptions, modelling and graphical presentations. In the following each of the 13 sub-projects are briefly described.

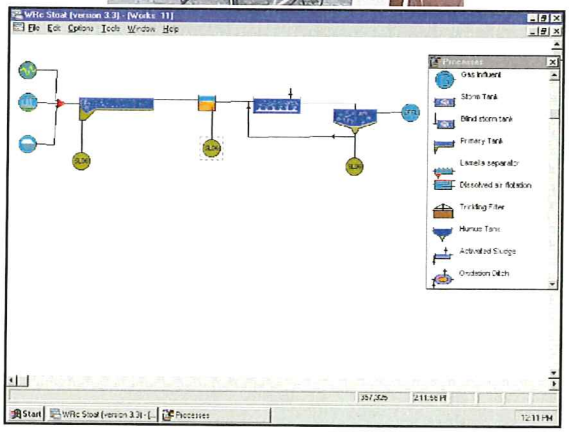
Three figures from the project work are shown below. The findings are based on chemical analyses, computer modelling, use of geographic information system (GIS), and practical evaluation of various water treatment methods.

Figure 1 (right): A JEPB representative taking sediment cores from the canals for analyses.

Figure 2 (bottom left): The GIS presentation demonstrates the suggested new sewer network on a digital map.

Figure 3 (bottom right): The computer model "STOAT" was used for dynamic modelling of the sewage treatment process.





2. Sketch of a Master Plan for WW management

2.1 Theoretical assumptions based on Norwegian experience

The master plan sketch contains a substantial amount of demographic, environmental and technical information about Jiaxing. Additionally, it explains how a master plan is developed in Norway, and may give practical information for city officials in the future.

The main function of a master plan for wastewater management is to be a decision and analysis tool for the city administration when implementing or up-grading the sewerage system in the city. In addition, the plan expresses interrelations and interactions between the use of water resources, water quality standards and quality goals, and presents costs and other economical aspects. Therefore, the plan acts as an important tool for decision-makers at top city level, as well as for high-level politicians, in order to prioritise issues within environmental management.

For the regulatory authorities, the plan should be an essential tool for evaluating the progress made by the community in creating a cleaner environment, and to control that the water quality standards are met in time and at the decided cost-level.

In master plans, the importance of a comprehensive overview and thorough panning, which includes municipal (domestic) discharges as well as discharges from industry (point sources or hot spots), rural areas and agriculture (diffuse sources), are strongly highlighted.

A master plan is valid for a limited period of time. In Norway, a master plan is commonly valid for 4 years. The plans are linked to the Municipal plans with a longer time perspective. The master plan is the foundation for specific, highly detailed Action plans, which are updated annually.

2.2 Examples for a Master Plan for WW Management for Jiaxing

The second part of the master plan document starts with a presentation of relevant aspects of Chinese environmental law, local frame conditions and financial options. This is followed by a description of the current situation in Jiaxing with regard to water quality and quantity. The Chinese State authorities give pollution prevention and treatment of "Three rivers, three lakes and two zones" the highest priority within environmental protection issues, and the Taihu Lake is among these. In the subsequent section the very important "Ninth five-year' plan of Zhejiang provincial water pollution prevention and treatment" and "long-term objective for year 2010" is presented, together with a description of each of the main watersheds in the area and the pollution sources. A brief introduction of the new wastewater treatment plant and wastewater collection system is also given. Finally, there is a presentation of how design data for the new treatment plant is collected by operating a pilot plant, and by advanced computer modelling.

Even though some decisions about technical solutions have already been made in Jiaxing, JEPB and NIVA still believe our proposed idealised planning process can be quite useful for the city to conduct systematically planning and follow up of the future expansion of its wastewater system. All new planning processes should have a basis in the existing systems to be sufficiently specific and realistic to be useful for the future. By doing well-founded planning it should be possible to construct and maintain an efficient, reliable and cost-efficient wastewater system in Jiaxing.

In the main document, there is a description and evaluation of the current situation based on the different water resources, pollution sources, technical installations, management, and institutional and financial options. Furthermore, future water quality goals, wastewater regions, pollution sources,

wastewater transport system and a suggested wastewater treatment system are described in a comprehensive manner. Finally, expected improvements of the local pollution situation in the canals and further system developments are presented.

This sketch of a master plan for the wastewater sector in Jiaxing is developed in close co-operation between NIVA and JEPB. This document contains a large amount of details and data about demography, industry, pollutant concentrations and regulatory issues, which form the basis for this project. It is assumed that this report also can be a useful source of information for other planning and consideration purposes in the Jiaxing metropolitan area.

3. Water Quality Status and Resource Management

This activity has covered data compilation, abatement strategy related principles and simple model running. Furthermore, it suggests future work on water quality related issues. This activity documents that the nutrient and organic loads into the canals are too high, and that the canals do not have natural capacity to manage the loads from sources such as sewage and industry. It is necessary to develop a comprehensive Abatement Plan, taking account of the existing water quality, user interests and future water quality goals for the canal system.

3.1 Data compilation

In view of the fact that integrated catchment management (in this case integrated canal system management) has not reached an advanced stage in this region to date, the data compilation, with indications of which data to compile, has taken a considerable part of the activities of this part of the project. It is, however, of importance to consider the specific parameters and their concentrations in water, the water flow, population densities, discharges of specific parameters from industrial plants, barge traffic, information about agricultural practices and land-use, user interests as a holistic approach.

One main achievement in this activity has therefore been the first general compilation exercise successfully performed by JEPB in order to understand this holistic approach, and the common understanding of data sources necessary for water quality related work, as well as the procedures for categorising data gathered.

3.2 Abatement Strategy

Water resources development and management are planned in an integrated manner, incorporating environmental, economic and social considerations. An Abatement strategy is a comprehensive methodology to use in the management of rivers and lakes to reach a better water-quality.

This project has resulted in a preliminary rough screening of easily available monitoring data and industrial sources lists, to identify the most important water quality problems (e.g. eutrophication/organic load, hazardous substances). Such a screening facilitates the data collection process by focusing on parameters qualifying the identified problems. This has been carried out during the project both for the purpose of wastewater treatment facilities and for the quantification of the pollution load to the canals.

Thereafter, the water quality is defined on the basis of the Chinese water quality classification systems. The classification of quality status should be based on measured concentrations that have two components; a natural component, which stems from natural processes in the catchment area, and a

component, which stems from human influence, *e.g.* effluents from industry and sewage, and agricultural runoff. The latter is defined as 'pollution'. The information provided about the natural component has been scarce.

The next step is to set water-quality goals. These should be set on the basis of user interests (drinking, fishing, irrigation etc.) and the goals related to aquatic life. The more detailed mapping of existing user interests has been carried out by JEPB.

The basis of a sound Abatement strategy is the catchment area. Discharges/losses of pollutants located upstream Jiaxing have effects and influence the situation in Jiaxing City. On a larger scale, it is therefor not sufficient only to look at pollution sources within the city, but also upstream.

The project has managed to provide an outline of an abatement strategy for use in a future more specific detailed goal orientated strategy.

3.3 Model running

QUAL-2E is probably the most commonly used water quality model today. The original version of QUAL2E, which is shareware on Internet, could not handle the conditions in Jiaxing. The QUAL-2E model has been adapted for NIVA purposes. The Jiaxing situation was used by running this model in the first half of the project time with some preliminary simulations. The model is made for river system and needed special coding to handle the canal network in Jiaxing.

At a later stage, NIVA was asked not only to produce simulation results, but also deliver the model for later use in Jiaxing. As the NIVA version of QUAL-2E would be difficult to use without continuous support from NIVA in the future, it was decided to use the WASP model. The WASP model includes user manuals that can be downloaded freely from Internet. The model is probably the most flexible water quality model in use. However, the input of data is complicated and time-consuming (DOS-based model).

The eutrophication part of the model was used. That included possibilities to handle nutrients, oxygen and algae. Focus was on phosphorus, nitrogen and biological oxygen demand (BOD). The situation in 1995 was simulated, with mostly observed data to represent the situation today. Thereafter the simulations were related to the situations in 2000 and 2020 with data that should represent the suggested population and industry developments. The simulations were made to study the effect of the planned wastewater treatment plant. Furthermore, simulations were made that took account of the effects of the "circular canal" around the city. Each of these alternative scenarios was studied for low-, mean- and high water flow.

The yearly input values for the model running were provided by JEPB. The data extrapolations were based on personal experiences with the local conditions. In order to simplify the work, the same values for water flow and input concentrations of relevant parameters in the waters coming into Jiaxing have been used for the various scenarios. This to show the effects of changes (e.g. changes in discharges/losses) within the city area, independently of changes outside this area (e.g. changes in inflow). Future simulations would benefit from taking account of different inflow concentrations and water flows. See the main report for an example of one simulation.

4. Preliminary Evaluation of an Alternative Location for Wastewater Treatment Plant no 1 (WWTP-1)

Based on the status of the canal water, NIVA has advocated for discharging the sewage into the ocean instead of into the canals. The work of the first half of the project period was based on the assumption that a number of wastewater plants should be constructed within Jiaxing City. During the project period, the city officials abandoned the idea of constructing smaller wastewater treatment plants (WWTP) inside Jiaxing, but started instead the planning of a large regional WWTP at Hangzhou Bay.

4.1 Location debate

This activity was initiated by JEPB at the onset of the project early 1997 to assist them in an ongoing discussion with the Jiaxing Construction and Planning Commission (CPC) about the location of the *Northwest* wastewater treatment plant (WWTP) in the city. This plant was one of three planned WWTPs in the city. CPC wanted to uphold the original location close to the newly constructed ring canal in the outskirts of the city. This alternative was called Alt. A. Many of the existing sewer lines were directed towards this location.

JEPB on the other hand wanted to consider an alternative site location (called alt. B) some 5-km to the Southeast of the alt. A - for two reasons:

- The site is closer to the city centre. Hence alt. B can serve the majority of the city at a quicker pace than Alt. A.
- Alt. B is closer to the sea (Hangzhou Bay). Sewage treatment near Hangzhou bay will be the long-term solution for sewage management, not only for Jiaxing but also for its surrounding 5 counties.

Both alternatives had its merits. The long-term regional plan presumes transport of all untreated sewage from the region to Hangzhou Bay South of the city, with treatment at the shore before disposal into the sea. The main disadvantage of alt. A was its location North of the city. By implementing alt. A the sewage for a limited period would be brought North of the city for treatment, until the sewer system again would have to be redesigned in order to lead all wastewater to a new regional treatment plant at Hangzhou bay South of Jiaxing.

4.2 Decisions

The Norwegian-Chinese project (NCP) was about to analyse the impact of discharging treated sewage from the two locations (alt. A and alt. B) to the two different recipients. The municipality of Jiaxing then decided to implement the larger regional scheme called the Ocean Discharge alternative (OD) directly – thus eliminating the necessity for analysing the two local alternatives any further. It should be noted that the NCP strongly recommended analysing and evaluating the Ocean Discharge alternative.

This project activity thus contains a short discussion of the two local alternatives, without going into an impact analysis.

5. Impact Assessment of Combined Wastewater

There is a large proportion of industrial, potentially toxic wastewater in the untreated sewage that will be led to the new WWTP. After having conducted comprehensive computer simulations and long-term operation of a model treatment plant (pilotplant), NIVA concludes that the new WWTP should be constructed as a stepwise constructed treatment plant, with possibilities for future expansions and modifications. NIVA suggests that the fist step is a so-called "chemically enhanced pre-treatment process (CEPT)", that should be followed by a second biological treatment step, at a later stage.

5.1 Background

Wastewater (WW) treatment processes are usually sensitive to industrial WW. The presence of some industrial WW in the influent to the WWTP may result in a non-optimal treatment process or may even completely hamper the process and cause serious environmental and economical problems. It has been estimated that the WW in Jiaxing consists of 50-70% of industrial WW, a fact that clearly indicates the seriousness of the problem.

Since beginning of this main activity there have been several decision-making stages, which have motivated the project group to gradually move focus from local wastewater transport and treatment strategy to a regional solution called the Ocean Discharge alternative.

The main objectives for this project activity was:

- To establish basic documentation and knowledge for impact assessments of industrial WW to the planned Ocean WWTP in general and in Jiaxing City especially.
- To evaluate the robustness of WW treatment processes to combined WW by pilotplant experiments and labscale tests (chemical and biological), together with modelling and simulation work.

In order to achieve the main objectives, following activities have been carried out:

- A general evaluation and recommendations regarding pre-treatment of industrial waste water.
- Collection and editing of existing and measured WW quality data (computerised). Adaptation and preparation of all WW data and results in a database for presentation in the ArcView (a computer based geographic information system/GIS). Evaluations, calculations and modelling/ simulation of future loads to the planned Ocean Wastewater Treatment Plant (OWWTP).
- Pilot plant experiments and labscale tests.
- Evaluation, design, modelling and simulation of suggested OWWTP process configurations.

5.2 Results

The main results and conclusions from this activity are:

- Management, pre-treatment and control/follow-ups of discharge standards requirements for industry wastewater and commercial wastewater must be a priority task.
- Collection and adaptation of data concerning infrastructure, industries, population, recipients has been edited into a Geographical Information system (GIS). The project group has used GIS as an effective tool for identification and evaluation of different management strategies.
- A study of existing and estimated future wastewater discharge loads from population, commercial and industry has been carried out.

- Labscale and pilotplant experiments have been carried out in Jiaxing City for a period of one year. According to the project team these test results and experiences gained have been of vital importance in order to reduce the uncertainty in design of the planned ODWWTP.
- Selection of design strategy and design loads, sketch design, modelling and simulations of the planned ODWWTP have been carried out.
- The planned drainage area to the future ODWWTP is a fast growing region related to population, commercial and industry establishment. The project group suggests a step-wise development of the OWWTP in order to develop a flexible and efficient system.
- A sketch design of a process based on chemically enhanced pre-treatment (CEPT) with an extension based on biological treatment has been carried out. The CEPT process is based water treatment by chemical precipitation with the use of low dosages of a metal salt and organic polymers.
- A wastewater treatment plant computer program called STOAT was frequently used in this project, including training and case studies done by JEPB. The computer program was used for the design and simulation of the OWWTP including a simple sewerage model. A one-year simulation with year 2010 as design year has been accomplished.

The results indicate that the suggested design with CEPT followed by biological treatment will meet future effluent requirements for the OWWTP.

6. Cleaner Production Study in Selected Industries

During the project the important potential for cleaner production and reuse of materials in various industrial plants was identified. Utilising waste products from industry for water treatment was also investigated, but was unfortunately in this case found to be too expensive.

6.1 Background

One of the objectives of this project activity was to introduce *Cleaner Production* as a method to reduce pollution loads from industry in Jiaxing City.

This methodology was demonstrated by making an assessment in two industrial companies in Jiaxing city; one pulp and paper mill and one textile factory, in order to point out the possibilities for improving the environmental performance, regulatory compliance and competitiveness through cost-effective preventive measures.

6.2 Methodology

Cleaner production is a preventive environmental strategy. The purpose is to prevent or reduce pollution and waste generation by implementing measures that are both environmentally sound and economically profitable.

In the past, pollution problems were mainly managed by «end of pipe»- solutions, a strategy that put considerable financial strain on the companies. Furthermore, «end of pipe»-measures do not really solve the pollution problem, because the waste is merely turned into another form, for instance from water pollution to solid waste. Nor does this strategy solve the problem concerning scarcity of natural resources such as water and non-renewable energy sources.

By employing techniques that emphasise reduced consumption of water, energy and raw materials, reduction of pollution and waste generation can be achieved in an economically favourable way. Such techniques may involve in-house cleaning of polluted water streams with subsequent recycling of water, energy recovery, replacement of old production equipment with new water and energy efficient production equipment, recovery of raw materials and products from waste streams, as well as improved management and house-keeping procedures and worker training.

6.3 Results

This limited study in two factories in Jiaxing has shown that there is a considerable potential for pollution reduction through cleaner technology.

In the study, the emphasis was put on options for water saving and reduced discharge of wastewater. Such options have been described for both the participating factories. I addition, options for reduced consumption of chemicals and energy savings are described.

Some of the options require none or negligible investments and could be implemented within a short time. Others require funds for modification of equipment or new production and treatment equipment and must be subject to more thorough feasibility studies.

The described options are examples based on a relatively superficial survey of the factories. Before implementation, the measures should be analysed with regard to environmental, technical and economical aspects. The analysis must be based on the situation in the factory and its surroundings.

It must be emphasised that this study is limited and do not bring to light all possibilities for employing cleaner production in the participating industries. Moreover, as the staff and employees in the factories did not play as active role as could be desired, the approach could be improved. *This work should be continued and expanded to further explore the potential for improvement through cleaner production techniques.*

7. Planning of Wastewater Collection Systems and Design Alternatives

A sewage collection system based on a combined ring-pipe in the Centre of Jiaxing with separate sewage pipelines in the surrounding areas is suggested. This system will minimise the transport of runoff water from paved surfaces to the WWTP, and at the same time be cost-efficient. The collection system leads all sewage to a main trunk sewer to the new WWTP.

7.1 Background

An important issue in the Jiaxing metropolitan area is to determine some basic principles for design of the sewer system in Jiaxing and train technical personnel on simulation models. This chapter describes an example of sewer design for the sewer system in Jiaxing.

The design example is based on discharge of treated sewage to the ocean. The HYDRONET programme carried out the hydrotechnical calculations for the presented example. Staff members of JEPB/JESI as a part of the training program on simulation models mainly carried out this work.

Tasks:

- Collect and adapt required design data, including computerised mapping of existing and planned main pipelines, main industries, main population density and main canals.
- Perform basic design of the WW collection system.
- Train technical personnel at the Jiaxing EPB and City Engineering Department on simulation models.

7.2 Results

The following have been achieved:

- Geographic presentation of existing and planned WW collection system, including discharges from population and industries.
- Training of JEPB-engineers in using advanced modelling tools for design of the sewer system.
- Basic design of sewer network has been suggested.

The example suggests some basic principles for design of the sewer system in Jiaxing:

- The separate system areas discharge to one main collector. The alternative to this solution would have been to route some of the separate systems through the main Centre ring pipe. However, this would give increased discharge of sewage to the ring canal during rainfall.
- The combined storm water and wastewater from the Centre area is pumped to a combined sewer overflow (CSO) a certain distance from the ring canal. A main CSO for the Centre area will ensure the sewage from the separated areas priority to the treatment plant during rainfall. The positioning of the CSO gives the smallest amount of sewage discharge to the ring canal.
- The principles described will give a minimum overall CSO to the canal system and will minimise the CSO to the ring canal and is therefore recommended as the best environmental solution.
- The sewage system is designed with pumping stations as the Centre drainage point in each of the collection areas. From these locations the wastewater is pumped with a pressure pipe to a main collector.
- The principle described reduces the needed amount of pumping stations and or makes it possible to reduce the trench depth. This will in most cases be the most economical solution in flat areas.

8. Wastewater Treatment Using Industrial Wastes

8.1 Introduction

Use of industrial wastes to treat wastewater is one of the most sustainable ways to rehabilitate and maintain the environment. By using coagulants produced from industrial wastes for wastewater treatment a similar concept can be demonstrated. To implement this concept it is necessary to introduce a wastewater treatment process based on coagulation, and a coagulant production concept based on industrial wastes.

Traditionally, the domestic wastewater in China is treated by biological methods. Common constraints associated with biological methods are toxic effects cased by industrial wastewater, low process activity in low temperatures, high volume requirements and little flexibility for expansions. Usually chemical wastewater treatment can manage all these problems. Chemical WW treatment is not common in Jiaxing, ever though there are industrial wastewater treatment plants using aluminium sulphate. The technical knowledge about this process and operational optimisation are low. These issues need to be addressed for a successful application of chemical WW treatment.

Being a city with many industrial activities, Jiaxing has by-products and/or waste products containing iron and hydrochloric acid, which are the main components in the iron-based coagulants. In Scandinavia these wastes are efficiently used for the coagulant production, and a similar activity has been identified as beneficial for Jiaxing.

8.2 Results

The coagulation process is introduced as a robust and economical alternative for wastewater treatment. A pilot scale coagulation process plant has been constructed, and the relevant personnel at JEPB have been given training in the process basics. JEPB personnel have been trained in using laboratory and pilot plant applications to plan, perform and evaluate similar tests on their own.

The coagulation efficiencies on various wastewater types commonly found in Jiaxing are studied in laboratory and pilot scale units. A mixed wastewater type with an anticipated wastewater quality at the WWTP prior to the ocean discharge is also evaluated. The results show that the domestic wastewater could be well treated at 10 mg-Fe/l, while the mixed wastewater demanded 4-6 times higher dosages, if stringent treatment goals are to be met. However, with lower iron dosages in addition to small dosages of organic polymers still a significant reduction of suspended solids and COD could be anticipated according to the CEPT (chemically enhanced pre-treatment) concept. The CEPT concept has successfully been implemented at the new WWTP in Hong Kong.

A survey on all raw material required for a local iron-based coagulant production was conducted in Jiaxing and suburbs, and as well as on industrial facilities. An initial evaluation of the eligibility of iron-sources was evaluated by Kemira Kemi AB to be positive. However, the current production concept can not compete with the low Al-based coagulant produced from an industrial waste at present, thus production plans were abandoned.

9. Stepwise Development of Treatment Plant

9.1 Background

Jiaxing City and its surrounding regions are developing integrated municipal and industrial wastewater treatment strategies. A highly recommended strategy is to develop treatment plants step-wise. The WWTP plant (or plants) to be built must therefore be designed in a way that allows cost-effective upgrading to higher removal efficiencies at a later stage. Step-wise planning and construction also gives advantages with respect to flexibility in the future. This approach provides valuable process information about the wastewater itself and the chosen first step configuration, before further treatment steps are chosen.

In order to select the optimal WW treatment strategy the overall economy for the various processes has to be considered. It is recommended to use estimated unit costs for removal of specific pollutants as a guide for the further strategy on a regional basis.

This activity gives an overview of a strategy based on step-wise development of WWTP, with European and local cost estimates. It also includes an example of a sketch design of a suggested first development step, based on one of the earlier suggested strategies for wastewater treatment in Jiaxing city with local treatment of Jiaxing north-west cities waste water (abandoned alternative, ref. activity no. 3 and 4).

9.2 Results

The following have been achieved:

- Suggestion and description of a step-wise development strategy for waste water treatment plants.
- Overview of assumed efficiency of various WW treatment methods.
- European and Chinese cost estimates for waste water treatment plants, and unit costs for step wise development (upgrading).
- Sketch design example of new municipal wastewater treatment plant, following a step-wise development strategy.

10. Institutional Strengthening

10.1 Background

The chapter describes subjectively the observed changes in status of the Jiaxing Environmental Protection Bureau (JEPB). One should bear in mind that the entire Chinese environmental administrative system underwent rather dramatic changes at the time the project in Jiaxing took place – between 1996 and 2000. All levels from SEPA (which at the outset was named NEPA) on down to the city and county levels gained status, competence and recognition as an important player on the local scene. We recognise this development in many countries including Norway. The participating institutions feel that the Norad-financed project has played a major role in the forming of regional development in the greater Jiaxing area on water pollution abatement actions.

It is important to make a clear distinction between institutional **strengthening** and institutional **building.** The Chinese administration has long traditions, even in the environmental sector. The environmental protection hierarchy follows the pattern of other administrative hierarchies repeating the same units from the national level on down to the county level. Jiaxing EPB belongs on the third level, between the provincial level and the county level.

In the beginning there were some doubts on the Chinese side whether the project belonged on the third or the second (provincial) level. Most of the other Norwegian funded environmental projects in China were anchored on the province level.

In hindsight after three and a half years of co-operation, we feel certain that for several reasons this project was correctly placed. Firstly the project even called a demonstration project, has a very technical, feasibility type approach. The city and region of Jiaxing were under heavy pressure to move forward on several serious water-pollution problems. The project was started at the same time as the city, undergoing a major economical and physical expansion, discussed several alternative approaches to solve the pollution-problems in the canal-system. The alternatives spanned from how many treatment units were needed for treating the wastewater, to localisation and technological issues.

10.2 Results

The most important building block for institutional strengthening is in our opinion, the mere duration of the project where a combination of technical, cultural and social relationships can be developed over time.

The project has also contributed in a more tangible way by furnishing JEPB with hard- and software-solutions as well as with other modern tools and equipment for assisting in the planning process of water pollution control measures. There have been several exchanges of personnel visiting Norway of shorter and longer duration, giving key personnel the opportunity to observe and participate in Norwegian practices. During the successful study trip to Norway in 1998 by a highly skilled group of experts from Jiaxing EPB the Norwegian ways of dealing with water-pollution were presented in various forums. During this trip the social ties between the project partners were undoubtedly strengthened, which we felt was crucial for the success of the project.

Aside from the rather extensive equipment purchases and the social bridge-building between the partners, we have a strong feeling that the most important criteria for a successful institutional strengthening is the mere time-span that has elapsed from the inception to the finish of the project. It has been said many times in various annual reports that the project should be regarded as a process rather than results with pre-defined indicators.

The following tools and education have JEPB taken advantage of as a result of this project:

- New computer facilities
- Internet and e-mail facilities
- Upgrading of telecommunication facilities
- New office furniture
- Upgrading of laboratory equipment
- Various knowledge transfer
- General computer education
- Advanced computer use (models, GIS)
- English education
- Experience with the design, construction and operation of a pilot plant
- Establishment of a useful monitoring database
- Training program in Norway

11. Preparation of a Methodological Guide

11.1 Introduction

China has a large number of middle and small size cities, which face considerable problems related to water pollution caused by industrial and municipal wastewater. With the development of industrialisation and urbanisation and the increasing awareness of the impact of such developments, the public pays more and more attention to environmental issues.

Many Chinese cities are facing a great challenge to solve the problems related to integrated wastewater management. The history of simple sewer, primary treatment facilities and the treatment of industrial pollution sources create difficulties for centralised treatment of wastewater. There is a great challenge in trying to develop a well-planned management system of wastewater.

The rencounter in a technical, scientific project such as the project on "Integrated Management of Industrial and Municipal Wastewater in China. - Demonstration Project in Jiaxing, Zhejiang Province", is not only the rencounter between people of different scientific background, but also between people of different socio-economic and cultural background. It is important to bear that in mind throughout the project period.

11.2 Experiences

This project has shown that the preparatory phase of a project such as the project on "integrated management of industrial and municipal wastewater—a demonstration project at Jiaxing, Zhejiang province" is of uttermost importance. Good preparatory work will greatly facilitate both the scientific part of the project, but may also overcome any scepticism towards foreign culture and different working methods.

When planning a project it is important to have a common understanding of the task/the problems to be solved, and to clearly define the objectives of the project. Knowledge should be acquired prior to the starting-up of the project on:

- Inter-institutional conditions in the area
- Choice of treatment requirements related to recipients, regulations and economy
- Current local and regional treatment processes

The linguistic related problems should not be neglected, as they concern not only the direct communication between the involved scientific people, but also the foreign people's access to the necessary documentation. The availability of highly competent interpreters and translators is therefore an issue that should be given priority.

Furthermore, it is important to establish a good dialogue between the scientific environment and decision-makers.

Reliable and sufficient background (historical) information is of importance. The data compilation phase should therefore be carried out carefully. It is also important to explain why the data is necessary, i.e. for which purpose, how will the data be used.

The value of such a project is therefore not only result-based as regards the design of a industrial and wastewater management tool, but also very much related to the principles and methods applied.

The Guide should primarily:

- Facilitate the work in the starting phase of projects similar to the project on "integrated management of industrial and municipal wastewater—a demonstration project at Jiaxing, Zhejiang province".
- Provide an outline of the general principles of integrated wastewater management.
- Point to potential problems in the running of similar projects in China.
- Suggest solutions to such problems.

On the technical side, the Guide intends to provide:

- An overview of the technical achievements of the project.
- Information on appropriate software for design of wastewater treatment plant technology and sewerage purposes.
- A concept of a master plan of a municipal wastewater project.
- An outline of integrated management of industrial and municipal wastewater.
- A method of pilot plant experiments for wastewater treatment projects.

The answer to which process should be used in the treatment of wastewater with complicated compositions and difficult biodegradation pollutants is often difficult to give. The situation as regards the aquatic environment and the economy may also differ from one city to another. It is therefore important to have a clear concept and a good understanding of the problems to be solved.

Experience shows that the application of computer assistant design software packages combines pollution sources, pre-treatment, standard for discharge into sewer, collection system, treatment plant and water capacity beneficially to increase the precision of design and the ability of integrated management.

This project has used:

- ArcView to establish GIS for pollution sources
- Hydronet to design the sewer system
- STOAT to design the WWTP
- WASP5 to simulate/predict the quality of the aquatic environment

GIS related information might be:

- Infrastructure related (canals, roads, highways, bridges, villages, names of places and so on)
- Pollution sources (point and diffuse sources)
- Quality definition of the environment (classification of water quality, air quality)
- Objectives for the environment (water, air and noise)

For the entire water pollution sector the most important step in disseminating methodology in a broad sense is the translation of the book "Urban Wastewater Projects – A layperson's guide" published by the European Environment Agency (EEA) into Chinese. NIVA feels that this achievement will provide the Chinese reader, who may have a wide spectre of responsibility in the water pollution sector, with modern systematic and holistic approaches to a wide variety of tools for planning and implementation of actions.

12. Dissemination of results – Jiaxing

Knowledge transfer has been a substantial part of the project in order to enhance future usefulness the project output, together with exchange of methods used to solve problems. Findings from the project have been presented in numerous Chinese seminars and meetings throughout the duration of the project.

This section highlights the most important events during the project life span. The project has undoubtedly given JEPB status and visibility in the internal municipal government of Jiaxing, which has been an important achievement. Furthermore, the project has been presented and discussed in numerous events in China, as well as in Norway. The project has been presented at national and international conferences, seminars and trade- exhibitions.

Of these we will mention the Environmental Seminar in Beijing in March 1999 where the Norwegian and the Chinese Environmental ministers were present. The final dissemination seminar in Jiaxing in January 2000 gathered broad attendance and formed the basis for locating similar projects in other provinces in the Peoples Republic of China, according to the government's policy of developing the Western parts of China.

The dissemination of results is among the most important sub-tasks in such a demonstration project. Dissemination is also an activity that draws on all the other activities of the project. The objective is to create and produce sustainability of the project. Another objective is to identify suitable candidates for new implementations of similar projects with preferably reduced input from the Norwegian side.