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**PROBLEMS AND COUNTERMEASURES OF THE MIN RIVER WATER
RESOURCES**

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Abstract

Because of urbanization, industrialization and the rapid population growth in Fujian, P.R.China, the inappropriate utilization and management of the Min River water resource stands out and becomes one of the important factors that restrict the economy and society of Fujian Province to develop. In this paper, characteristics and problems of the Min River water resource were illustrated, reasons which cause the problems were analyzed and corresponding solutions, including government policies and further recommendations, were brought forward.

Key words: the Min River, pollution, water quality, environment, wastewater, countermeasures

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Foreword

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Introduction

Since China's policy of opening and reform was adopted, the economy and society of Fujian Province has been developing quite rapidly. But this development occurs on the background of limited space and resources, especially in terms of water resources. The combination of rapid economic growth and the use of disadvantaged production technologies and practices have caused serious pollution of Fujian's limited water resources. As the main source of freshwater for Fujian residents, the Min River plays an important role in the process of Fujian's development. On the one hand, with its limited runoff, the Min River is taking the responsibility of providing water resources for production and people's living; on the other hand, thanks to the natural features of the Min River and artificial factors, the water resource has not been exploited and utilized as fully as expected. The extent to which the Min River is exploited and managed can be viewed as one of the signs of Fujian's progress, both economically and socially. As the regional economic and social structure stabilizes and the contradiction between supply and demand of water resources become obvious, the issues with regard to the water resource protection and water environment of the Min River start to attract people's attention.

As early as the period of the Eighth Five-Year Plan (1991-1995), it had been expected that good quality water would be a national goal in the near future. Till nowadays, indications have come to show that the challenge of achieving good water from the Min River has been met with success to some extent in Fujian. The Min River is the case study to harness a polluted river and provide safe drinking water; the problems are associated with management of the river, wastewater discharge and treatment facilities, as well as governmental efforts to improve the overall quality of water available to the residents of Fujian Province. The purpose of this paper is to seek to scientifically manage the Min River water resources for the well-being of local population, and at the same time to provide a guideline to aid the efforts of NGOs and other organizations interested in the conservation of water resources. In order to expound the object mentioned above clearly, I induce the following questions. What are the natural characteristics of the Min

River? What problems of the water resources exist? To what extent the Min River has been polluted? Why is it so difficult to bring the pollution of the Min River water resources under control? What are the governmental policies? Whether the governmental efforts are fruitful or not? Any other better countermeasures for harnessing and managing the Min River water resources? The paper will answer the questions one by one.

In this essay, Chapter 1 first introduces the current situation and problems of the Min River water resources, including five parts. Part one describes the water resource conditions of the Min River to make readers attain basic preknowledge, or a blueprint, of the Min River water resources in general. Part two tells readers the facts about the Min River and illustrates the characteristics of the water resources in natural and artificial aspects by providing concrete first and second-hand information about the situation of water resources. Part three analyzes the causes for the change of ecological environment of the Min River in both history and reality contexts. Part four tries to illustrate the current pollution of the Min River water resources. And the last part in Chapter one analyzes the definite causes for the difficulty in controlling the water pollution.

Chapter 2 tries to find out the methods for harnessing and protecting the Min River water resources and countermeasures for wastewater treatment. In the chapter, the overall objective is firstly described, and secondly theories which can be applied to solve the problems in reality are listed. Though none of them are elaborated in a detailed and complete way, I believe most readers are familiar with them. The last part is going to thoroughly layout countermeasures for the utilization and management of the Min River water resources. In this part, the governmental operational strategies and solutions in reality are first illustrated, and then some recommendations follow. And at last a short conclusion summarizes the paper.

Methods and sources of data are discussed in the fieldwork report.

1. The current situation and problems of the Min River water resources

1. 1 The situation of water resource conditions of the Min River

The Min River is the major waterway in Fujian Province, People's Republic of China, which flows through 38 different counties and cities (including Longquan County and Qingyuan County in Zhejiang Province, which is to the north of Fujian Province), and its drainage covers about half of Fujian Province. With a basin area of 60,992 square kilometers (including the basin area of 1,070 square kilometers in Zhejiang Province), the Min River is the river with the largest basin area within the offshore marine areas in Southeast China.

With a numerous tributaries, the Min River has a well-developed river system. Within the region of the upstream portion of the Min River, there are Jian Creek (Jian Xi), Futun Creek (Futun Xi) and Sha Creek (Sha Xi), three important tributaries. But where is the exact place of source of the Min River? There used to be various statements in the past and present literature. According to the inspection report provided by Fujian River Source Inspection Group(FRSIG) set out for the source of the Min River, Fujian Province, in 1992, it is now confirmed that the its source is located at the southwestern slope of Yanfeng Mountain in Taitian Village, Junkou Town, Jianning County, which is located in the upstream portion of Sha Brook at the east side of Wuyi Mount (FRSIG 1992) On the basis of this fact, specialists measured the length of the main stream of the Min River, and it is 562 kilometers, from the source to Changmen (a village located in the offshore county of Lianjian, Fuzhou).

Research Commission for Natural Resources in Fujian (RCNR) provides relevant information about geographic features of Fujian Province as follows. The terrain in the northern region of Fujian Province is special, descending gradually from the northwest to the southeastern seaboard, just like a flight of stairs. Within the region, countless mountains tower aloft, mountain ridges meander, hills undulate, and small basins scatter here and there among mountains. The general configuration of the earth's surface contains the patterns of medium mountains, low mountains, hills, basins, valleys and plains. In the process of new tectonic movement, the region used to break off along or

cross countless folding axes, forming a lot of cracks, whose main directions are north-east, north-east-north and north-west. Gradually, a huge amount of rivers appeared along cracks, composing a bent checked river system. (RCNR 2001:3-13)

The climate in the region of Fujian belongs to middle subtropical zone monsoon climate, temperate and moist and rainy; annual precipitation is as high as 1,700-2,300 millimeters, making Fujian one of the rainiest provinces in the southeast offshore marine area in China. In the mountain areas, the water conservancy is fast, and in flood seasons, the volume of runoff accounts for three quarters of that in the whole year. The water volume in the Min River basin area is 57.5 billion cubic meters, accounting for 55.4% of the total volume of water discharged into the sea (Zhang 2004:97-99).

The distribution of the Min River runoff is relatively concentrated within a year and in flood seasons the runoff accounts for 75%~80% of the annual volume. During this period, the two main weather systems of plum rains and typhoon storms influence the runoff greatly; during the plum rains seasons (from April to June), the runoff accounts for 35%~60% of the annual volume, and the distribution tendency appears a gradual descent from mountain areas in northwest to offshore marine areas in southeast; the runoff in typhoon storms (from July to September) accounts for 20%~25% of the annual volume, and the distribution tendency appears a gradual descent from offshore marine areas in southeast to mountain areas in northwest. The runoff in dry seasons (from October to March next year) just accounts for 20%~25% of the annual volume. So here is a distinct geographical regularity. Water resources of the Min River are influenced by the relationship of precipitation and runoff. In history, the average annual runoff coefficient in a simultaneous term is fluctuating between 0.40~0.70, reflecting the hydrometric physical features of the Min River (Zhang 2004: 100-109).

1.2 Characteristics of the Min River water resources

1.2.1 The stability function of various annual evaporation on land in Fujian

Fujian Province is located in a rainy, mild and moist area. The key law of keeping the balance of water quantity in the basin area lies in the stability of the yearly variety of evaporation. This new concept, does not only make a breakthrough by shortening the applied sample series greatly, but also clarifies the quantitative or qualitative relationship of the statistic parameters of the three volumes of water resources (precipitation, runoff of rivers and creeks, and groundwater compensation from permeating precipitation), theoretically, which reflect the characteristics of natural law for the quantity of water resources in Fujian, objectively.

1.2.2 The function of groundwater compensation from permeating precipitation

The cycling of groundwater runoff is much slower, compared to the cycling of surface runoff. As a result, the former owns the property of easy utilization. For this reason, the majority of cultivated land is irrigated by channeling or pumping water that mainly comes from groundwater compensation in Fujian. During the dry seasons, the Min River's capacity of keeping the necessary water quantity and maintaining water transport greatly depends on the groundwater compensation. Trees grow densely in the region of North Fujian, and the vegetation cover is as high as 70%~80% (the provincial average level is 62%). So the water quantity can be guaranteed efficiently. According to measuring and surveying by specialists, within a basin area of 1,000 square kilometers, in the saturation zone under the forest land, the quantity of the water regulated and stored could reach 150 million cubic meters. (RCNR 2001:15) Consequently, protecting the vegetation plays an essential role in richening the flow capacity of rivers.

1.2.3 The natural and artificial causes for floods and droughts

In Fujian Province, the water resources vary greatly, both yearly and seasonally, and the water quantity in a dry year just accounts for around one third of that in a water-high year. The water quantity in flood seasons is relatively concentrated, which is the main cause for the frequent floods and droughts. Because of the destruction of the forest vegetation several times in history, which weakens the water conservation function of the basin, the

conservation volume of the groundwater at the low layer and the compensation volume for rivers are both influenced, worsening the situation of droughts. The Min River floods are mostly caused by rainstorms in the plum-rain seasons, so floods usually appear in June, a few appearing in typhoon seasons (in July). Based on information provided by Research Commission for Natural Resources in Fujian, the five fierce floods of the Min River took place in 1748,1952,1961,1962 and 1968 respectively. In history, 1963, 1967 and 1971 were dry years, whereas 1952, 1954, 1973 and 1975 were water-high years.(RCNR, 1991:5) The Min River floods are mainly decided by weather system of rainstorms, but artificial large-scale deforestation speeds up the runoff on the surface, leading to a greater effect of flow capacity when flood waves come. Due to this characteristic of the Min River, placing stress on undertaking new water conservancy projects, protecting vegetation cover and bringing rivers under control would be a long-term task.

1.2.4 The deposit of soil and sand shallows the waterways day after day

The yearly variation of sand-bearing amount is not only influenced by the runoff at the same year and the ability of bearing mud and sand, but also has a tight relationship with human activities. Especially the human activities in the upstream region, such as destroying woods and reclaiming wasteland, severe deforestation, mining stones to construct roads and discharging waste into rivers without any treatment, etc, have greatly influenced the rising of the riverbeds and the increasing of soil & sand in rivers. Based on the survey taken in Zhuqi hydrometric station at the Min River, the annual average volume of sand-bearing has increased 45%, and on average the volume of sand transmission increases 2.42 million tons every year, with an increased sand transmission modulus of 44 tons per square kilometers. Due to the increasing sand-bearing volume in the river water, the problem of deposit in the waterway is becoming serious day by day. For instance, the Nanpu Creek (Nanpu Xi) in the upstream portion of the Min River used to be a water transport channel. But now because of the deposit, wooden sailing boats have stopped doing business. During the period of floods in 2005, the water level at the section of Zhuqi used to rise 0.2~0.3 meter, and the water level rose to 0.5 meter at Wusi

Road in the downtown of Fuzhou, the capital of Fujian, where pedestrians couldn't go through. (Work report from Zhuqi Hydrometric Station 2005:3)

1.3 The analysis of ecological environment change of the Min River

1.3.1 The influence of artificial causes on ecological environment

Since 1980, as a vanguard province in the reform and opening in China, Fujian's social economy has been developing fast. The living standard of masses has risen quickly, and thoughts and ideas of people have changed a lot. Under these circumstances, for ecological environment, the influential system and intervening pattern of social economic activities have been different from those in the semi-closed society before 1980, whose mode of production was relatively disadvantaged.

Before the 1980s, economic activities brought great pressures on ecological environment. And there were two reasons. One was low-level agricultural cultivation for the purpose of adapting to fast growing population, and the other one was the exploration of mountains and oceans guided by governmental administration, such as "Large land reclamation" taking cultivating grain as a outline and reclamation of "small plains" by masses in formalist movement of "Learning from Dazai", and large-scale deforestation because of the "Big-scale steel-making" in 1958, leading to a vast amount of soil erosion.

After the 1980s, as the change of economic system appeared, a great transfer gradually took place both in influential system and mode of intervention for ecological environment:

--activities of exploration intervene in ecological environment, but the intervention form is transferred from scattered self-sufficient demand domination to concentrated commodity-sufficient demand domination;

--ecological affects caused by social economic activities is transferred from agricultural activities domination to many activities in estates and sections functioning mutually;

--ecological affects caused by engineering behavior in the form of unified order is transferred to ecological intervention and destruction caused by regional exploitation driven by local or sectional interest, lacking unified regulations.

1.3.2 The influence of over-cultivation and exploitation of land

Because of the development of cities, residential areas and transport, the area of industrial and mining land increases very fast. Fujian is a mountainous province, with a very few plains. Large population, residential areas and farmland have densely covered the numerous basins and shallow valleys. Nowadays, with the development of economy and the increased population, even the land on the slopes of 25 degrees or above has been exploited and cultivated in some places. The development of market economy and the implement of separation policy of land-owning right and use right both accelerate this process of transfer, driven by comparing and utilizing different economic returns. The area of non-agricultural construction land increases, as well as the number of related geographical hazards, such as soil erosion, collapses, silts, mud-rock flows, etc. Exploiting non-metal mines at the surface layer, such as granite, pyrophyllite, and lime, etc, leads to flowing sand, raised riverbed, worsens the water quality of the Min River greatly, and brings about many defects.

1.3.3 Over-deforestation and deterioration of forest ecology

In the aspect of afforestation, in order to attain the short-term interest, a large scale of fast-growing coniferous trees, such as fir woods and mason pines, are cultivated, leading to serious phenomena of too many conifers growing in forests. As a result, the forest ecological system deteriorates; the quality of forest descends; the structure of forest evolutes in an unhealthy direction; and the ecological function weakens.

Especially in the region of North Fujian, people breed dried mushrooms and edible fungus on a vast scale. For instance, Gutian County breeds 180 million packages dried mushrooms and edible fungus every year. Based on the fact that 1000 packages edible

mushrooms consumes 1 cubic meters broadleaf woods, breeding these edible mushrooms in Gutian equals a consumption volume of 180 thousand cubic meters broadleaf woods , meaning a yearly growth volume of 200 thousand square hectares broadleaf forest land. These years, in order to promote the development of local economy, a few counties and cities in Nanping region have installed 7 new production lines of medium-fibreboard, with a total construction scale of 260 thousand cubic meters per are, an atural production capacity of 412 thousand cubic meters per are and an increasing amount of a wood consumption volume of 618 thousand cubic meters per year (based on 1:1.5). As a result, every year several million cubic meters of natural broadleaf trees are consumed. Over-deforestation weakens the capacity of unit-area water storage and the function of protecting water sources directly. And this increases the harm of natural disasters to some extent, for example, floods and droughts are happening in the Min River basin area with increasing frequency.

According to what is analyzed above, the influential factors for the change of ecological environment in the Min River basin area ask for decision on measures to guarantee the quality of the Min River water resources according to the special circumstances.

1.4 The current pollution situation of the Min River water resources

In the Min River system, the total length of the rivers divided by 275 water environment functional zones is 6120 kilometers. Of these functional zones, there are 5 type I zones, with river sections of 185 kilometers in length, accounting for 2.98%, 45 type II zones, with river sections of 405 kilometers in length, accounting for 6.52%, 191 type III zones, with river sections of 5420 kilometers in length, accounting for 87.28%, 9 type IV zones, with river sections of 65 kilometers in length, accounting for 1.05%, 24 type V zones, with river sections of 130 kilometers in length, accounting for 20.9%, and 1 mixed zone, with a river section of 3.2 kilometers in length, accounting for 0.08%. (Zhang 2003:24) See figure 1 for the division of water environment functional zones.

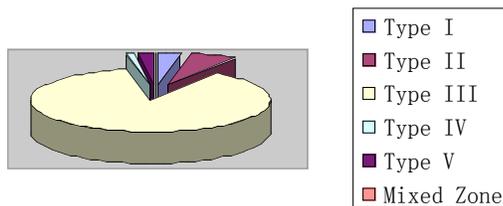


Figure 1. River-length proportions of different types of water environment functional zones in the Min River basin area

1.4.1 Pollution from industry

Owing to the development of industrialization and the lack of people's consciousness of environmental protection, the volume of untreated wastewater discharged into rivers increases, leading to the deterioration of water quality. On the basis of relevant statistics information: in 2001, throughout the whole Fujian Province, the annual discharge volume of industrial wastewater broke through the level of 1.1 billion tons; the discharge volume of industrial waste gas roared to 12.98 million cubic meters; and the output of industrial solid waste increased to 45.34 million tons. During the period of 1998-2001, the growing rate of the discharge quantity of "three wastes" from industry had exceeded that of industrial additional value. In the city of Yong'an in the upstream portion of the Min River, the discharge amount of wastewater was as high as 5.67 million tons per day. And the runner-up was the Fuzhou city, whose discharge volume of wastewater was 4 million tons per day. So there is no doubt that the Min River had been polluted. According to the latest data measured during first two weeks in October, 2005, it was illustrated that the water quality of the Min River had been bettered to a certain extent, but some individual sections were still contaminated seriously. "Fujian water resources bulletin" released from Fujian hydraulic information website especially illustrates that there is a worsening tendency for the water quality in the upstream portion of the Min River water system.

There are 33 inspection stations located in this water system in total. The 23 river

sections, whose water quality achieve the set standards, account for 69.7% of the total inspected river sections, and the rest 10 river sections which are polluted account for 30.3% of the total inspected river sections. All of the polluted river sections are within the two tributaries of Sha Creek (Sha Xi) and Dazhan Creek (Dazhan Xi). Except that water quality in Xingping section is of type III, the water quality of the rest sections in Sha Creek is of IV or V type. The main pollutants are Ammonia Nitrogen and Total Phosphorus. From 27th, January, 2002 to March, large amounts of dead fish appeared in Sha Brook continuously. During this period of sudden event, relevant departments monitored the polluted river sections and found that Ammonia Nitrogen level and Total Phosphorus content had all exceeded the standard of type III set by “Surface Water Environmental Quality Standard”.(Cai Deqi & Wang Kaiming 2003:25-30).

Table 1. Water quality inspection on key sections of the Min River basin area October, 2005

Name of place	Situation of cross sector	Inspection items					Type of water quality	Main pollutant
		PH	DO(mg/l)	COD(mg/l)	TP(mg/l)	NH3-N(mg/l)		
Shuifen Bridge	Sha Creek (cross sector at Sangming-Nanping)	6.78	4.00	2.0	0.048	0.49	<input type="checkbox"/>	DO
Zhuqi	Main stream (cross sector at Nanping-Fuzhou)	6.55	6.26	2.9	0.083	0.30	<input type="checkbox"/>	
Baiyan Pool,Changle	Main stream (cross at mouth)	6.93	7.88	2.5	/	0.21	<input type="checkbox"/>	

PH: Acid & Alkaline Value DO: Dissolved Oxygen COD: Chemical Oxygen Demand
 TP: Total Phosphorus NH3-N: Ammonia Nitrogen

Abstracted from “Environment and Development Newsletter” Fujian, 21st October, 2005

1.4.2 Pollution from agriculture

According to the amount of pesticide distributed by agricultural goods and materials companies both in counties and cities in Fujian in 2003, the average sales volume was over 52.8 thousand tons throughout the whole province, including 22 thousand tons Organic Chlorine and 27.2 thousand tons Organic Phosphorus. Pesticide consumption per mu was 2540 gram (1mu=1/15 square hectares=2000/3 square meters), and 22.5 thousand tons high-poisonous pesticide throughout the whole province, making Fujian one of the provinces that consume too much pesticide. (Zhang Ruiyao 2004:87) Contamination

parameters of organic substance reflected in the water bodies, especially the poisonous substances, include phenol, cyanogens, arsenic, mercury and chromium (six-valance). The length of the river sections in which the amount of phenol exceeds the set standard of water quality (phenol content is 0.01 milligram per liter) is 85.5 kilometers throughout the whole province, which is mainly located in the region of Sha Creek in Sha County. Accidents of water resources contamination happened frequently. For instance, on 3rd November 2003, Gutian paper mill discharged a large amount of black liquid and high-poisonous sulphate into the Min River directly, leading to countless dead fish floating on the surface of the river from Gutian to Yeyang (the length of the river section is 108 kilometers), and the total weight of the dead fish was over 15 thousand kilograms. (Zhang Ruiyao 2004:90)

1.4.3 Pollution from animal husbandry

At present, the constitution of pollutants is changed obviously. Animal husbandry has become the chief pollution source in the basin area. According to survey and calculation by specialists, the animal husbandry in the Min River basin area generates 301.7 thousand tons wastewater and deals with 150 thousand tons wastewater every day, which means that just around 50% of the generated wastewater is treated before discharge. And within the wastewater, the Chemical Oxygen Demand discharge volume of 760.35 tons per day and the Ammonia Nitrogen discharge volume of 76.57 tons per day are 5.7 times and 7.5 times of those within the industrial wastewater in the basin area, respectively. Especially of the animal husbandry in the region of Nanping City, the Chemical Oxygen Demand discharge volume and Ammonia Nitrogen discharge volume account for 70% and 54% of those within the whole basin area, respectively. (Zhang Ruiyao 2004:34-45) The animal husbandry produces too much pollutant, but the waste treatment and utilization ratio is quite low.

1.4.4 The factor of unsound environmental protection infrastructure

The cities and towns develop fast, but the construction of urban environmental protection

infrastructure has still lagged behind obviously. According to inspection and calculation in 2003, the discharge volume of residential wastewater in the Min River basin area was 987.2 thousand tons per day, and 354.5 thousand tons was dealt with per day, with a disposal ratio of 35.9%. Within the residential wastewater, the Chemical Oxygen Demand discharge volume of 322.66 tons per day and the Ammonia Nitrogen discharge volume of 34.73 tons per day were 2.4 times and 3.4 times of those within the industrial wastewater in the basin area. (Zhang 2003:25) At present, within the Min River basin area, there are still many problems, such as a large amount of unplanned discharges and low-efficient wastewater drainage pipes in the existing sewer networks. The harm-free treatment of residential garbage doesn't work well. Within the whole basin area, except the cities of Yuan'an, Sanming, Nanping and Fuzhou, no other cities or counties have built any garbage treatment plants to make garbage harmless. In the established ones, there are still bad phenomena, such as over discharge of percolation liquid and groundwater pollution. Besides, problems, such as township refuse incineration facilities could not be operated stably as expected, have not been solved properly.

1.4.5 The factor of step-by-step exploitation of water and electricity

As the step-by-step exploitation of water and electricity develops fast, the harm of ecological destruction is becoming outstanding. Based on incomplete statistics, there are as many as 29 large-scale or medium-scale water power stations and hundreds of small-scale ones in the Min River basin area. Just within the region of Nanping City, the number of small water power stations is 183, including the ones being constructed or will be constructed in a near future. But most of these water power stations haven't gone through the formalities of environmental examination and appraisal. The development of water power stations has changed the natural characteristics of the Min River basin area to some extent, leading to the slow-down of current velocity, obvious reduced self-cleaning capacity of water bodies and the sustained deposit of pollutants. Now water bodies in all reservoirs have been hyper-entrophic to a certain extent. Most of the water power stations are not able to guarantee the minimum volume of down-flow in accordance with the requirements, leading to the lack of ecological environmental water

in the downstream and the sharpening pollution of water quality. At the same time, the air temperature is increasing in recent years, making the water bodies hyper-entrophic and water hyacinth over grow.

1.4.6 The factor of deforestation

Though the cover of forest vegetation in the basin area is relatively high, the forest structure is not so reasonable. Many natural woods have been cut down. According to measurement and calculation by specialists, thanks to the soil erosion in the Min River basin area, among the surface pollutants blushed into water bodies by rainfalls, Ammonia Nitrogen accounts for around 6.7% of the total pollutants in the whole basin area, and Total Phosphorus accounts for around 15.8%. Every year, 13 thousand tons Ammonia Nitrogen and 5.8 thousand tons Total Phosphorus in chemical fertilizers and pesticides are being washed away, accounting for 21.3% of Ammonia Nitrogen pollution and 28.8% of phosphorus pollution in the basin area.(Zhang 2003:24-26)

In a word, the situation of water resources of the Min River has attracted the attention of masses and the government, and protecting water sources and ecological environment and controlling contamination have become very urgent missions.

1.5 Why is the pollution of the Min River water resources difficult to control?

1.5.1 The factor of economic development

Economic development enlarges the burden on environment quickly. According to the goal of constructing a prosperous society, it is predicted that by 2010 the gross domestic product in the Min River basin area will be 1.6 times as much as that in 2004, (Fujian province will realize its prosperity goal 3 years earlier than the whole country), and by 2017, the gross domestic product will be 2.8 times as much as that in 2004. The Min River water environment capacity measured and calculated illustrates that by the end of 2004, respectively, the volumes of Chemical Oxygen Demand and Ammonia Nitrogen in

water pollutants in the whole basin area had increased to 38.2% and 86% of the load under which the water environment can function as normal.(Zhang 2004:74-76) In another word, if the traditional development mode is still kept, environmental load (consumption amount of resources and discharge amount of pollutants) of the Min River basin area in 2010 and 2017 will be around 1.6 times and 2.8 times as much as that in 2004, respectively, which makes it difficult to last the original environmental capacity.

1.5.2 The factor of urbanization process

The acceleration of urbanization process will make the construction of environmental infrastructure facilities face new pressure. The Min River is quickening the pace for urbanization, and it is predicted that the urbanization level will have reached 54% by 2010, and the urban population will be 1.3 times as much as that in 2003. In 2017, the urbanization will reach the level of 63%, and the urban population will be 1.6 times as much as that in 2003.(Zhang 2004:80-88) Without adopting efficient measures to accelerate the process of environmental protection, it will be difficult to meet needs for future urbanization development, and the problem of urban water and garbage pollution will be more and more serious.

1.5.3 The factor of mode of management

The extensive mode of management will still restrict the improvement of water environment. Although recently the structural adjustment in the Min River has been fruitful to a certain extent, the extensive mode of growth hasn't been changed thoroughly, and production mode of high consumption of energy & material and high production of pollutant hasn't been transferred. There are still many key industrial enterprises located in the basin area, and the volume of their Chemical Oxygen Demand discharge accounts for 48.2% of that of industrial pollution throughout the whole province, and Ammonia Nitrogen discharge volume accounts for 49.8%.(Zhang 2004:89) Developing animal husbandry would still be one of the main development channel for agricultural production, and the tendency of using chemical fertilizers and pesticides in large-scale can't be

brought under control efficiently in a short term. Pollution caused by animal husbandry and runoff of chemical fertilizers and pesticides would still be two of the most important restriction factors for improving the quality of water environment.

1.5.4 The factor of natural ecology

The natural ecology is still fragile. Because of the existence of mountains and hills in most of the Min River basin area; the terrain undulates greatly, with big drops in elevation; soil layers of hillocks are usually thick, which can be easily eroded. In addition, monsoons and storms lead to full and intensive precipitation, making this geomorphologic environment be destroyed easily. Once the vegetation cover suffers destruction, soil erosion will happen easily, and ecology will deteriorate very fast and be difficult to be restored.

1.5.5 The factor of poor supervision

The industrial value of output in the Min River basin area accounts for about one third of the total value of output throughout the whole province, making it a region where industry develops intensively. Because of the weak supervision capacity of environmental protection and the disadvantaged measures, there is a lack of efficient supervision and control over medium-scale and small-scale enterprises, in addition to other factors, such as insufficient punishment regulations, low cost for illegal activities, pool consciousness for law-abiding, difficult law enforcement, some enterprises setting private pipes and discharging wastewater into rivers illegally, it is inevitable that the phenomena of over-discharge still exist.

2. The countermeasures for protecting and managing the Min River water resources

2.1 The overall objective

The overall goal is that, on the basis of current water environmental protection, great

efforts should be taken to implement relevant governmental strategies and carry out various projects (personal recommendations mentioned below in detail) which are good for the wastewater treatment and protection of the Min River water resources, in order to improve the quality of water environment unceasingly. In a short term, the water quality of Sha Creek section should be improved greatly, and the water quality of the whole basin area should basically reached the set quality standard of water environment in functional zones. The quality of drinking water supplied intensively in places of source should reach the set standards in all aspects. The tendencies of environmental pollution and ecological violence have been taken under control efficiently. And in the long term, the quality of water environment in the Min River basin area should be steadily maintained in a good state, and the ability of sustainable development should be strengthened greatly. It is necessary to construct the Min River basin area into a sustainable development zone, in which economy and society develop fast, living environment is beautiful and comfortable, ecological environment evolutes all round, human and nature coordinate harmoniously, because civilized development includes not only growing production and prosperous life, but also good ecology.

2.2 The theoretical basis for the research on the management of the Min River

There are different theories that may explain the causes of the problems discussed above and the solutions to be explained below. They have been well referred to when Hainan Province, Jilin Province, Heilongjiang province compiled “Outline for Construction of Ecological Provinces”. (Cai Deqi & Wang Kaiming 2003:2-9).

At present, Chinese people are required to lay stress on establishing a harmonious society, which includes the harmoniousness between human and society and the harmoniousness between human and nature. In order to deal with the problems of the Min River water resource, sustainable development theory, circular economy theory, ecological economy theory and systems engineering theory should be applied specifically. In order to take practicable measures, it is necessary to observe the characteristics of water quality and the pollution situation of the Min River basin area in an all-round way.

2.2.1 The theory of sustainable development

The phrase of sustainable development first appeared in some articles and documents from some developed countries in middle 1980s. And since the World Commission on Environment and Development (WCED) in the United Nations defined sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987:43), it has emerged as an important new qualification for environmental infrastructure projects, particularly on the fast-growing and environmentally underserved areas. Nowadays, the thoughts of “using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.” (Commonwealth Government, 1990) implies that the needs of a population and the flow of resources needed to support them are in dynamic balance. With these principles in mind, one can explore how the concepts of sustainable development may be applied in developing communities, like Fujian, that historically lack wastewater infrastructure throughout China. This new standpoint of development combines the immediate interests with long-term interests, the partial interests with the general interests, organically and wholly, leading the economy of Fujian to be able to develop along a healthy track. For this reason, as a principle rule from beginning to end, the theory of sustainable development lays solid foundations for relevant human activities, such as people adopting new and advanced measures to harness the Min River and transferring extensive economic growth mode to intensive one in the ecological environment construction of water quality of the Min River.

2.2.2 The theory of circular economy

The concept of circular economy first appeared in some industrialized countries in late 1990s. Compared to traditional economies, it is a new economic form, standing for a kind of developmental tendency of newly-emerging economies. Circular economy is a creation after human being’s introspection for the traditional development mode that is hard to be kept up, and an inevitable product of social improvement. The essence is: in the way of “be friendly with the environment”, people utilize the natural resources and

environmental capacity to realize the ecological transfer of economic activities, change the traditional production procedure of “resource--product--consumption--pollution discharge” into the a substance repeating and cycling procedure of “resource--product--consumption--reproduction”, and improve the utilization of resources to the most feasible extent to avoid the environmental pollution. (Wang Jinnan 2002:8) This theory should also be an important theory when we research on the protection and utilization of the Min River water resources. It is embodied in many aspects in this paper, such as the economic operation mode of low wastewater-discharge, Eco-industrial Parks, clean production, and so on. The theory is guidance for people who try to increase utilization ratio of water resources, alleviate the water resource shortage and environmental pollution pressure, and develop water resource recycle & reuse.

2.2.3 The theory of ecological economy

Ecological economy is a subject of frontier science fused by economic development and ecological environment protection & construction. It views the objective world not only in the natural or social perspective, but also in the comprehensive perspective combined by the two. Ecological economy reveals the developmental rule of compound system in ecological economy, so as to coordinate the relationship between economic activities of human being and natural ecology, and seek the channel through which ecological system and economic system can adapt to each other and both develop harmoniously. Natural resources are not exhaustless, and human being and the nature should be connected as a whole. As Lester R. Brown argues in his book, our generation made the choice to restructure the economy in the time available, and it will affect life on earth for all generations to come. (Brown 2001:3-9) The process of exploiting and managing the Min River doesn't just refer to human activities at the moment; it reminds people of the tense relationship between economy and ecological system. If the current situation of poor water environment in the Min River basin area is not changed, increasing economic losses caused by deteriorating ecological factors will lead to economic recession some day. So this generation must regain the initiative by developing ecological economy in reality before that day comes.

2.2.4 The theory of Systems Engineering

Systems engineering means an organic entity with particular functions, consisting of two or more components acting and depending on each other. It possesses six basic properties: entirety property, interrelation property, objective property, system property, dynamic state property and environmental adoption property. When people study systematical development and manage the water resources of the Min River, they must widen the field of vision, not just pay attention to the system itself, but also include the settings and background of the system, make overall planning by taking all factors into consideration. In this way, the exploration and management of water resources of the Min River will involve all walks of fields, like economy, society, environment, resources, technology and funds throughout the whole province inevitably. It is obvious that the scientific guide of systems engineering is a useful tool.

2.3 The countermeasures to exploit and manage the Min River water resources

2.3.1 Governmental strategies of placing water resources protection and pollution treatment side by side

Recently, the central government points out that, in the field of water resources, Chinese people are now faced with four severe challenges in a long-term: (i) the natural calamity of floods is still one of the most terrible disasters for the whole Chinese nation; (ii) the contradiction between supply and demand of water resources is becoming more and more obvious; (iii) the soil erosion is very serious; (iv) the water pollution hasn't been controlled efficiently. The practical actualization of the issued laws, such as "Environmental Protection Law of the People's Republic of China" and "Law of the People's Republic of China on Prevention and Control of Water Pollution", illustrates that Chinese central government has paid great attention to the problem of water resources environment.

In the Eleventh Five-Year Plan (2006~2010), the Chinese government will strive to solve

the problems of poor-qualified drinking water and serious drinking water shortage in certain areas. By 2020, China tries to attain an adequate supply of safe or basically safe drinking water to residents. According to the requirements of this Plan provided by the central government, in order to develop and save the Min River water resources and harness pollution, Fujian government has decided to emphasize on: (i) strengthen the protection of water sources, water quality and ecological system of the Min River; (ii) strengthen the management and administration of township industry and village industrial zones; (iii) pay great attention to the job curing the environmental pollution in cities.

In reality, some achievements have been obtained in protecting the water resource environment of the Min River. For example, in 2000, 91.5% of the water quality of cross sectors at provincial inspection stations reached or exceeded the set type III standard of national surface water, 48 percentages higher than that in 1995, so the comprehensive ecological improvement did used to be carried out.(Zhang 2004:23-34) And in the process of implementing the three guidelines mentioned above, the governments at various levels have paid much attention to the construction of wastewater treatment plants. A large number of wastewater treatment networks are newly-constructed or rehabilitated, financing coming from the government, the whole society and the foreign funds. For example, in Fuzhou City, the capital of Fujian, five wastewater treatment plants (Yangli wastewater treatment plant, Xiangban wastewater treatment plant, Jinshan wastewater treatment plant, Mawei wastewater treatment plant, Kuai'an wastewater treatment plant), with a total treatment capacity of 340 thousand tons per day, have been established, which is good for slowing the deterioration of the water resources by discharging treated wastewater in the Min River.

Though the government's efforts cannot be denied, because the main environmental pollutants still appear time and time again, the tendency of water resources being re-polluted still exists. For example, in 2004, the proportion of reaching or exceeding the set type III water quality was 83% (the set standard ratio of water environmental function is 84.3%), 2.5 percentage lower than that in 2003.(Zhang 2004:65-69) Consequently, it is also true that the governmental work need to be improved, chasing for more efficient and

fruitful achievements.

2.3.2 Recommendations

Because the causes for the improper utilization and management of the Min River water resources are various and water environmental protection is a social and complicated cause, the countermeasures taken into consideration and applied in practice should be comprehensive. It is necessary to take the whole situation into account and plan accordingly, ensuring the realization of protection objectives and the key points of the job in a long term. Because of the deficiencies of the governmental work mentioned above, the following projects should be promoted as countermeasures in order to solve the existing problems of the Min River water resources.

Countermeasure one: Animal husbandry pollutant cleaning project

Technical skills and biological methods can be applied to promote the comprehensive treatment of animal husbandry pollution. The energy environment construction needs to be accelerated, reducing the waste from animal husbandry or making it harmless or synthetically useful. In the countryside, energy consumption structure should be improved, and people can try to develop animal husbandry in an intensive and positive way in order to increase the industrial effectiveness of agricultural and the income of farmers. First, in the basin area, all the cities and counties should be required to draw up a plan for the local animal husbandry development and pollution treatment. The suitable livestock amount and the rational distribution of stock farms are scientifically decided by the waste consumption capacity of the land. New construction, reconstruction and extension of stock farms should be conducted strictly in accordance with the system of environmental influence evaluation and environmental protection. Second, the establishment of animal husbandry forbidden zones can be put into effect as a legal system. Within the forbidden zones, no construction of stock farms is permitted; whereas stock farms should be operated in a large scale outside the forbidden zones. Besides, the original stock farms in the forbidden zones must be brought under control by

reorganizing, and reach the set standards before a prescribed time, otherwise they must be removed or closed-down without exception. Through this system, it is hopefully that, within a short period, the utilization ratio of waste from animal husbandry can reach a relatively high level in the whole basin area. Third, under the guidance of the government, farmers can try to spread advanced experience of three-dimensional ecological agriculture and animal husbandry to put an end once and for all to the problem of animal husbandry pollution. The combination of three-dimensional mode, such as “pigs-marsh gas-grasses-pigs” and “pigs-march gas-fruits (or vegetables, trees, edible mushrooms, fishes), and the comprehensive technologies suitable for the countryside leads to the proper treatment of wastewater before discharge, even making the waste useful in the process of production. These measures are in accordance with the requirements of circular economy theory and ecological economy theory.

Countermeasure two: Industrialization, and marketization of wastewater treatment & resourcelization of wastewater project

The former part asks for changing the traditional mode of raising funds for wastewater treatment projects and realizing the industrialization and marketization of wastewater treatment. The wastewater treatment plants are playing the role of important urban infrastructure. In the past, almost all funds were provided by the government, or in the form of accepting donation or foreign loans. After the wastewater treatment plants were put in effect, the government continued to manage them, throwing in more labor power and material resources. Just a little wastewater treatment fees which could not match the operational cost were collected by the government at the same time. Because the investment from the government is limited, the cause of wastewater treatment is restrained in the process of development. So formulating the policy of industrializing wastewater treatment can help resolve the problem of urban sustainable development. The industrialization of wastewater treatment allows some economic entities to invest capital in the construction and management of wastewater treatment plants and benefit from them. The models of circulating funds for the projects could be various, but in the recent years, the model of BOT is a new kind of structure in the development tendency of

circulating funds for the projects. BOT is the abbreviation of three words of “Build”, “Operate” and “Transfer”. In this model, the government grants the patent right of an infrastructure project to the contractor. In a fixed period, for instance, 30 years, the contractor takes the responsibility of designing the project, collecting funds, constructing and operating for the sake of retrieving the cost, paying the debt and making a profit. At the end of the period, the contractor transfers the integrated ownership of the well-operated wastewater treatment plants to the government. At the same time, it is necessary to solve the issue of marketizing wastewater treatment. The product of wastewater treatment is a public product whose consumers are the masses. So this industry can be fully marketized. Its theoretical foundation is grading the urban public infrastructure in accordance with five indexes, including the features of public consumption, charging right, equality of infrastructure services, competitive power in market and externality property.(Zhang Jun 2003:25) The marketization scope is fluctuating from 1 to 3. The projects with a marketization extent of 1.8 or above could all be operated in the marketization model. Most of the public facilities enjoy a marketization extent of 1.8 or above. So the projects of wastewater treatment could be operated in the marketization model.

The resourcelization of wastewater is also one of the channels to realize the sustainable utilization of water resources. On the one hand, the environmental pollution can be alleviated; on the other hand, the utilization ratio of water resources is increased, meaning an increased volume of water resources and an alleviated contradiction between water resource supply and demand. Wastewater treatment and regenerated water utilization can represent a good cycling of water resource utilization and an important measure guaranteeing the reduction of total water demand. So this is a definite application and a good example of sustainable development theory and circular economy theory.

Countermeasure three: Infrastructure for municipal and township environmental protection project

The government should has its feet firmly planted at bettering the environmental quality

both at municipal and township levels by fully applying the industrialization policies and absorbing capital from the whole society to invest in the environmental protection projects. At the same time, it should give energetic support to infrastructure constructions to deal with wastewater, garbage and dangerous wastes (including medical waste) in cities and towns. The capital for the building of sewer networks is encouraged to be absorbed from diverse sectors of the economy, and at least one wastewater treatment mill and one garbage disposal mill should be built in each city in the basin area. Relatively high wastewater treatment ratio and garbage disposal ratio should be included in key points of governmental work at different levels. In order to attain the goal of reaching the set standard of discharge, more advanced and practical skills and measures should be applied for sterilization and elimination of phosphorus & nitrogen in the process of wastewater treatment. In terms of garbage disposal, the experience of classified collecting and comprehensive utilizing can be promoted. To prevent potential re-pollution, it is reasonable to spread the practice of generating electricity through refuse incineration. By launching the movements, like “Establishment of Green Communities”, the purpose of constructing a beautiful and comfortable living environment for residents could be brought about.

Countermeasure four: Protection of key water sources project

The goal of this project is guaranteeing the safe residential water for the masses and the commercial water for industry and agriculture. The provincial government should ask the subordinate governments to firstly finish the compilation job of demarcating water source protection districts and report the result to the provincial government for approval. Besides, in terms of the protection of water bodies at source, and water and soil conservation through afforestation, definite requirements should be put forward as well. The protection of drinking water sources must be brought into line with the local economic and social development plan, in which methods about how to punish the activities ruining the water environment and ecological balance or destroying woods conserve water and protect banks are expressly provided. The management of water consumption can be strengthened by applying economic methods and price system to

coordinate the relationship between supply and demand of water resources. If the whole society is initiated to save water through carrying on the experimental construction of water-economization society and promoting the establishment of demonstration districts for modernized irrigation, the goal of protecting key water sources would be much easier. These should be carried on under the guidance of the systems engineering theory.

Countermeasure five: Promotion of clean production project

The prevention and control level of industrial pollution can be increased as the technology and science progress. Through adjustment of economic structure and strengthened management of industrial pollution sources, it is possible to realize the clean production and develop economy in the Min River basin area in a new-pattern industrialized way, in which the most of the labor resource works with high technology and science content, good economic benefit and little environmental pollution. The provincial government should require that the plan of promoting ISO14000 environment management system (ISO14000EMS) in the Min River basin area be formulated as soon as possible. For the sake of reaching the set standards in all aspects, all kinds of organizations and enterprises are encouraged to apply for the authentication of ISO14000EMS. Export and processing enterprises and key industrial enterprises are especially asked to promote this system in order to raise the level of clean production. Not just key enterprises should be authenticated by ISO14000EMS, throughout the whole basin area, the national and provincial nature preservation zones and places of historic interest and scenic beauty should start to carry out the authentication of ISO14000EMS as well.

Countermeasure six: Guarantee of ecological functions project

In order to attain the goal of keeping the ecological functions of the Min River basin area, aiming at the current glaring problem of ecological destruction, it is reasonable to spread a host of advanced experiences, such as improving the power stations step by step, regulating the rational limit of water resources development and utilization, distributing

water resources properly, establishing the unified water transfer mechanisms, unblocking the river courses, harnessing soil erosion, reorganizing the mining industry and exploiting the mineral resources more rationally, protecting the ecological woods, constructing the nature preservation zones and ecological function zones, keeping the variety living beings, maintaining the ecological balance and ecological virtuous cycle, giving full play to the ecological advantages, so on and so forth. The four theories are embodied well here.

Countermeasure seven: Circular economy pilot project

For the sake of cultivating and expanding the groups of industry, it is important to apply the developing thoughts of circular economy to the development of regional economy, constructions in urban and rural areas, and the process of production. In addition to the economization and comprehensive utilization of resources, through the establishment of experiment units in practice, including industrial circular economy experiment units, agricultural circular economy experiment units and ecological industrial zone experiment units, with great efforts, probing into the industrial chain of circular economy and all rational modes of co-existing groups of industry will produce the maximum optimized disposition of resources and minimum generation of pollutants. Enterprises are encouraged to realize the pollution control and reduce the pollutant discharge in the whole process of production through adopting advanced technologies and utilizing resources synthetically. Besides, promoting the demonstration of resource-saving skills is helpful to increase the industrial water reuse ratio in enterprises, greatly.

Countermeasure eight: Demonstration of ecological agriculture project

Taking the development of green industry in the upstream portion of the Min River basin area as an essential link, the government should accelerate the construction of ecological agriculture and devotes major efforts to promoting the ripe and applicable modes of ecological agriculture. On purpose to strengthen the competitive power in agricultural product market and promote the harmonious development of agriculture, rural economy and ecological environment protection, promoting and developing high-quality

agriculture, ecological agriculture and organic agriculture should be placed on the order of the day. The key points include:

(i) Controlling agricultural pollution. After scientific research, specialists formulate and regulate the standards of safe-utilization technologies for pesticides, chemical fertilizers and Plant Growth Regulator. Farmers are encouraged to develop the processing of biological organic fertilizers, adopting of “Green technologies” to eliminate injurious insects, and developing biological pesticides with high efficiency and little poison. In the aspect of freshwater aquaculture scope and layout, the arrangements should be made appropriately, because over-intensive and unpractical aquaculture also pollute the water bodies.

(ii) Carrying out ecological agriculture demonstration projects. In the light of ecological agriculture principle of “entirety, cycle, coordination”, a group of counties and villages along the main stream of the Min River or tributaries are being constructed as ecological agriculture and sustainable development demonstration units. As mentioned above, the Min River basin area is rich in mountainous resources, whose advantages can be tapped by spreading compound mode of ecological agriculture.

(iii) Constructing bases of organic food, green food and environmental pollution-free food and increasing the developmental level of ecological agriculture. In terms of the locations of the bases, the government ought to draw up a detailed plan and given priority to nature preservation zones, ecological demonstration zones, sustainable development demonstration units and ecological agriculture demonstration counties. Relevant branches will take the responsibility of monitoring the environmental quality of these bases periodically.

Countermeasure night: Environmental monitoring and supervising and international cooperation project

The government must emphasize on strengthening its capacities of environmental management, early warning and quick response. By perfecting the environmental monitoring and supervising networks and implementing the system of monitoring and

management of environmental emergencies, the level of modernized environmental management can be advanced and the safety of water environment of the Min River basin area can be ensured. What worth mentioning here is that, nowadays people adopt the Geographical Information Systems (GIS) and establish the data forum of water environment, providing comprehensive information about water environment, hydrology, pollution sources, meteorological phenomena and ecology, etc.

In order to harness and manage the Min River in a better way, it is intelligent to make use of foreign forces. In terms of expanding the exchange and cooperation with foreign companies and organizations, measures should be taken in all aspects. Studying and using the experience of international ecological protection and construction for reference is necessary. The strategies include:

- encouraging foreign companies to establish ecological research and development centers in the Min River basin area;
- absorbing foreign capital to carry on cooperative projects and combining the utilization of foreign capital with ecological construction;
- inviting famous foreign specialists and researchers to Fujian for academic exchange;
- introducing foreign investment to comprehensive projects of wastewater treatment, energy conservation and resource utilization;
- importing and introducing from foreign countries the improved strain of crops, advanced technology facilities and administration ideas positively;
- strengthening the exchange and contact between Fujian and Taiwan, and enlarging the scale of existing projects.

Summary and Conclusions

Water resource is one of the important factors that guarantee the living of human being, and is an essential substance that all living beings depend on. The Min River is an important river in Fujian Province. The Min River water resources satisfy the needs of hundred millions of people for residential water and supply sufficient water for the development of industry and agriculture. Though the Min River water resource is

relatively abundant, it is influenced by natural weather system and artificial management to a certain extent. The serious pollution of the Min River water resources has caused troubles for production and people's living. Even if the government has taken action in practice and some achievements have been attained in the aspects of wastewater treatment and water environmental protection, this contaminated river still asks for greater efforts on treatment and better management, and wastewater treatment still remains an arduous task for the coming years. As a result, harnessing and managing the Min River water resources is a task that brooks no delay. Fujian government is always striving to reduce the harm caused by the pollution of the Min River water resources. Though relevant guiding principles has been formulated, the enforcement situation is not so satisfactory. In order to handling these challenges efficiently, not only the government should take steps to manage the Min River water resources scientifically, but also the masses and NGOs should supervise the governmental efforts in this field. Under the theoretical guideline of sustainable development theory, circular economy theory, ecological economy theory and systems engineering theory, it is hopeful that the troubles brought about by the pollution of the Min River water resources can be solved through the co-efforts of the governmental organizations and NGOs.

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