APPLYING CIRCULAR ECONOMY ON POLLUTION REMEDIATION AND INTEGRATED MANAGEMENT IN DONGGANG RIVER BASIN, TAIWAN

Lu, Tai-Ying¹, Ting, Cheh-Shyh²

ABSTRACT

Donggang River has a total length of 44 kilometers at Pingtung Plain, Taiwan. It is a typical water-flowing river with an average daily flow of 2.06 million m³. It provides water for daily supply of 300,000 to 350,000 m³ of Kaohsiung City. In the past ten years, nearly 74% of the animal husbandry effluent pollution in the basin has caused serious water quality problems. Over the years, there has been no departmental integration mechanism and effective governance policies. This study is concerned about Kaoshiung-Pingtung water resources from the role of civil NGO and started to make progress over the governance with further analysis of Donggang River through several public and private meetings and discussions. After the discussion, a so called Circular economy model— an innovative multi-dimensional solution was formulated that converts pollution sources into resources for energy.

In addition, lots of efforts were made to enter the six-year Forward-looking infrastructure construction, starting in mid-2017. The project has been upgraded to the key management level of the Executive Yuan, and the case is expected to solve the problem of sustainable development of water resources through technical, policy and social interventions. From the perspective of policy framework, this forum will demonstrate the Circular Economy Model has solutions that have been proposed for many years of technological innovation, meanwhile to develop the governance of the integration of various departments. A model case for Taiwan's river pollution remediation was eventually established that simultaneously solves river pollution, creates renewable energy and resources.

Keywords: watershed integration management, circular economy, river pollution remediation, renewable energy.

1. INTRODUCTION

Pingtung County in Taiwan is a city dominated by traditional agriculture. Moreover, agricultural production relies mainly on animal husbandry, and there are a large number of farmers in the county who raise pigs, raise cattle and raise poultry. According to the "Number of Pigs Survey Report (2017.11)" issued by the Agricultural Committee of the Taiwan Executive Yuan, there are 1,710 pig farms in Pingtung County with 1,233,642 pigs, making it the second largest pig and animal husbandry county in Taiwan. For a long time, Pingtung animal husbandry is an important source of income for farmers. However, the smell of animal husbandry and the pollution of rivers have caused people's living environment unbearable. The main reason is that livestock farmers use traditional simple sewage treatment and government regulations. The emission standards are very lenient (in the case of COD, the standard is 600ppm). Even so, the livestock and livestock households are still not

¹ Doctoral candidate of Civil Engineering Institute, National Pingtung University of Science and Technology, Taiwan. (no.3, Ln140, Tzu-li 2nd Rd, Kaoshiung, 80046 Taiwan (R.O.C)); E-mail: luty1961@gmail.com
² Dean of the College of Engineering, National Pingtung University of Science and Technology, Taiwan. (1, Shuefu Road, Neipu, Pingtung 91201, Taiwan (R.O.C)); E-mail: csting@mail.npust.edu.tw
operating due to the fact that most of the sewage treatment equipment has not been updated for last 30 years. Of course, the discharge of wastewater is unqualified and causes environmental pollution!

Donggang River is the most important river in Pingtung. The total length is about 44 kilometers. The river area covers 17 townships in Pingtung. According to the survey from Ministry of Economic Affairs in 2011, Donggang River is filled with up to 90 percent of springs. The average daily flow is 2.06 million m³. Several decades ago, in order to solve the problem of lacks of industrial water usage in the south area of Taiwan, we collected water from the downstream of Donggang River in order to supply 300,000 to 350,000 m³ for Kaohsiung City. However, nearly 74% of the animal husbandry effluent has caused the water pollution index (RPI) higher than 6.0. The degree of pollution for purification field must spend a lot of money on ammonia and nitrogen treatment. However, it still often fails to meet the standard point of water quality.

In terms of pollution prevention, it only rely on the inspection of the environmental protection department. However, there are about 371 pig farmers and 30 cattle farmers, with less than 30 numbers of government inspectors. The annual fine of animal husbandry effluent was nearly 30 million N.T. dollars, which is the highest fine in Taiwan. It is still impossible to stop the pollution by severe inspection alone.

In December 2014, the author served as the head of environmental protection bureau of Pingtung County, I promoted the “change” of livestock waste and excrement from energy-consuming treatment of pollutants into energy (biogas) and resources (fertilizer).

2. INNOVATIVE APPROACHES

This paper uses the innovative way promoted by circular economy model. Animal husbandry pollutants have transformed into a new sustainable green economy cycle as shown in the following figure.

![Figure 1. Schematic diagram of the strategy of transforming water pollution into sustainable agriculture resources.](image)

2.1 Promote Energy (Biogas) And Resources (Fertilizer)

Thirty years ago, Taiwan’s animal husbandry and urine were all used as resources (pig excrement as farmland fertilizer). In 1991, wastewater treatment facility was required for animal farming. However, traditional and simple sewage treatment are not up-to-date (in the case of COD, the standard is 600ppm). Currently, the three-stage treatment are: solid-liquid separation, anaerobic (gas-to-gas) fermentation and aerobic treatment. Most of the old equipment (over 30 years) cannot effectively treat the sewage. In addition, the electricity cost is often higher due to aeration and aerobic
treatment procedures. As the results, in order to save costs, sometimes the procedures of treatment cannot be completed. Moreover, for the applicants of livestock industry, the process of having pollutants treatment is too complicated. Therefore, under the low motivation of cooperation by farmers, it eventually leads to seriously river pollution.

In fact, wastewater from swine industry is high with organic and nitrogenous substances. The water-soluble substances produced by anaerobic digestion of animal husbandry and urine are biogas slurry, and the solid products are biogas residue. Biogas slurry and biogas residue are rich fertilizers, which can improve the growth of plants and resist to plants diseases. Farmers use biogas slurry and biogas residue as farmland fertilizers, which can reduce the use of chemical fertilizers, promote organic agriculture, and save considerable fertilizer costs.

There are examples as following:

1. Netherlands, Sweden and other countries have used animal husbandry wastewater for anaerobic fermentation and then applied it to farmland as a fertilizer. It has been used for decades, and contracts have been signed between pig farmers and farmers.
2. The EU has waste regulations for wastewater to the farm.
3. The United Kingdom identifies biogas slurry as a biological fertilizer, which can be commercially traded.

The environmental protection bureau in Pingtung county had suggested the Environmental Protection Agency (EPA) of the Executive Yuan to promote the “Water Pollution Prevention Measures and Inspection Report Management Measures” In this new policy, the usage of biogas slurry and biogas residue farmland fertilizers has expanded. In the beginning of 2016, with the assistance of EPA funds, a three-year promotion plan began in Pingtung.

After 3-year promotion, Pingtung county government figures out some strategies, which are able to convince people join the policy and break through the predicament.

A. Set up county counseling group for livestock (swine and cows) farmers

Pingtung county government set up a county counseling group consist of department of agriculture, environment protection bureau and environment consultants in 2017. The counseling group has given advices for 44 livestock farms, and 17 livestock farms had agreed to join the program of “swine wastewater as Farmland Fertilizer”.

B. Swine wastewater and irrigation

We have assisted to transport over 5,000 ton of swine wastewater for farmers in Pingtung county. Most of them said swine wastewater digestate is good for crops and no other bad effect so far.

C. Cooperate with agricultural technology experts to conduct trials in fields.

Participation of professors in National Pingtung University of Science and Technology
Results:

1. There is no obvious odor in the swine wastewater and Digestate process.
2. The nitrogen content of soil was increased significantly.

Professors had confirmed that positive effects on both the plants and the soil, and no need to worry about Cu, Zn remain in plants and the soil.

However, due to lack of phosphorus and potassium fertilizers during flowering and fruiting period, farmers should add these elements properly.

D. Integration of government resources increases allowance for livestock farmers.
Pingtung county government has set up plenty of allowance for livestock and herdsman to improve their wastewater treatment facilities every year.

E. Combine On-site Wastewater treatment projects to promote “Piggery/Swine Waste and Digestate as Farmland Fertilizer”

Since the seriously pollution of Donggang River, Pingtung county government has designed several “On-site” Wastewater treatment Plants along the river. One of them was located in Long Ching river drain system, and we are planning to plant grasses on the high riverbank. It’s another innovative idea to recycle livestock sewage.

2.2 Transformation of Agricultural Waste into A Biomass Fuel

The EPA Pingtung introduced a facility with “gasification cracking method” to treat the biomass waste, which also processes the cattle dung. The biomass pellet fuel rods (RDF-5) are produced by smashing agricultural wastes and cattle dung. In December 2018, a gas-fired power plant capable of processing 6-8 tons of agricultural waste per day, continuous operation gasification cracking furnace and 100KW operation for 24 hours was completed. This method successfully manages the waste pollutants derived from agriculture and livestock farming.

2.3 Integrated Governance with Donggang Creek Management

The above strategy of the agricultural circular economy model involves multiple departments at the central and local levels, and therefore, governance integration is in need. In mid-2015, the Department proposed the “2030 Donggang River Vision Project”, which takes into account the overall consideration of river water quality, water volume, waterfront living environment, and the above-mentioned circular economy model. In May 2016, after the election, the new government proposed the “National Prospective Plan” including major transportation, green energy, digital, water conservancy and environment in early 2017. The Pingtung County Government proposed a new plan of “the vision of Donggang River in 2030”. As a demonstration project for water and environment, it was led by the Administrative Council of the Executive Yuan to establish a platform for promotion, including the Agriculture Committee, the Water Resources Department, the Construction Department, the Environmental Protection Agency and the Taiwan Sugar Company.

3. RESULTS AND DISCUSSION

3.1 Promotion of Energy (Biogas) and Resources (Fertilizer)

The improvement of water quality has gradually yielded positive results. For example, Donggang River, its proportion of serious pollution decreased from 15.6% (2015) to
5.3% (2017) the proportion of less polluted stuff increased from 16.8% (2015 years) to 42.0% (2017).

Additionally, gang-shi pumping station, one of the EPA's key monitoring station, was also decommissioned in 2018 due to improved water quality (from severe to moderate).

In 2017, “Promotion of Swine Wastewater and Digestate as Farmland Fertilizer in Pingtung County” participated the “Standard Learning program” and being awarded by the Executive Office of the Personnel Administration of the Executive Yuan. Additionally, another ranking as excellence showed in the yearly water/soil/groundwater assessment in Taiwan.

3.2 Transformation of Agricultural Waste into a Biomass Fuel

A. The largest soy sauce company in Taiwan as an example, compared to the cost of heavy oil fuel which generate 10,000 tons of combustion heat for about 435 US dollars, the company saved 170 US dollars by using RDF. In addition, the company also reduced the air pollution fee in the second season.

Table 1. RDF is fuel, compared with the reduction of air pollution fee declared by heavy oil in the original factory

![Image of RDF to fuel comparison table]

Figure 2. 100KW biomass gas power generation equipment
3.3 Integrated Management Plan with Donggang Creek Governance as the Target

The integration of Donggang River is not only established by the Central Administrative Council, but also by the local government. The local government also has a platform for the integration of the bureaus. The meeting is held every two weeks regularly. "Donggang River Governance Project Office" was also settled for relevant supporting programs to achieve mutual governance goals.

In addition, through the meetings convened by the councillors, many of the restrictions of the laws and regulations were successfully resolved. For example, the Water Resources Department imposed restrictions on the irrigation of biogas slurry and biogas residue in the high reaches of the river. Through this platform, the restrictions of the law are resolved smoothly and quickly. In addition, many equipment such as gasifier equipment is restricted on agricultural land, and because of the communication and modification through this platform, the Agriculture Committee passed "Law of animal waste and agricultural waste recycling" in March 2018. A number of laws and regulations that hinder the recycling of the circular economy have been overcome.

4. CONCLUSION

After three years of promotion to solve the pollution of rivers with circular economy model and the combination with the platform of integrated management, we have successfully achieved the goal of recycling pollutants into resources and energy. The policy of reusing natural biogas slurry had been initiated from Pingtung. First, Pingtung County has promoted 123 livestock farms to participate in the policy of “Piggery Waste and Digestate as Farmland Fertilizer, it can reduce more than 600,000 tons of livestock waste per year (about 82,000 pigs) and it also reduces the problem of river pollution. However, the numbers of pigs in the 123 livestock farms are less than 1/10 of total numbers of pigs in Pingtung County. Therefore, the Pingtung County Government is still working with the Central Environmental Protection Agency to promote this policy by simplified application process. Besides, the Agricultural Committee has included biogas slurry and biogas in the condition of organic fertilizer allowance.

In 2016, new president of Taiwan specifically stated that the goal of recycling economy of resource and energy. However, in the past three years, the central government has not been in charge of the leading role to circular economy. Therefore, to achieve the ultimate goal of “cradle to cradle” zero waste, there is still a long road to go.

5. REFERENCES


