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Using Water Hyacinth to Clean Up Pollution: A Case Study from China

Strengthening local capacity in the economic analysis of environmental issues

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The excessive growth of water hyacinth is a key environmental problem in China. Water hyacinth is a noxious weed that has attracted worldwide attention due to its rapid spread and growth. However, when looked at from a resource angle, the plant appears to have several unique and potentially valuable properties. A new EEPSEA study assessed a proposed biogas project that has been designed to use the water hyacinth from one of the country's most polluted lakes. The study aimed to see if the project would be a cost-effective way to control water hyacinth, help clean up water pollution, and generate a source of renewable energy.

The study is the work of Zanxin Wang and Jin Wan from the School of Development Studies at Yunnan University. It finds that the proposed project is a good alternative to the current water hyacinth control method (i.e., disposal to landfill) because it is cheaper, avoids the production of methane emissions, and uses the water hyacinth rather than just disposing of it. While the biogas plant would not be self-supporting financially, the study recommends that it would be a good policy option as it provides a range of benefits to society as a whole, has the potential to help clean up the lake, and would produce a significant amount of sustainable energy.

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A summary of EEPSEA Research Report No. 2013-RR7: 'An Economic Analysis of the Use of Water Hyacinth for the Phytoremediation and Biogas Production in Dianchi Lake, China' by Zanxin Wang and Jin Wan. Comments should be sent to Zanxin Wang, School of Development Studies, Yunnan University, No. 2, Cuihubei Road, Kunming, Yunnan Province, 650091, P.R. China. Tel: + 0086 871 5036527. Email: wzxkm@hotmail.com.

The water hyacinth challenge

Water hyacinth is one of the most productive plants on earth. A mat of medium-sized plants may contain two million plants per hectare that weigh 270 to 400 tonnes while the biomass of water hyacinth can double every five days. The plant grows particularly fast in polluted water and vast rafts of the plant now clog up many water bodies in China.

One of the main problems associated with the control and use of the plant is that it is very expensive to harvest. However, it is thought that the high cost of collecting and removing water hyacinth could be offset by using the plant to generate biogas. What's more, water hyacinth removes excess nutrients from water as it grows. Hence, it can play a role in pollution remediation if it is harvested and disposed of properly. It can also play a role in carbon sequestration due to its rapid growth rate.

Despite the potential the plant is thought to possess, there is little information available on the feasibility of an integrated water hyacinth disposal project that capitalizes on its possible uses. To help fill this information gap, Wang and his team assessed the economic feasibility of harvesting water hyacinth to make biogas. To do this they undertook a cost-benefit analysis of a proposed biogas plant that would be fuelled by water hyacinth from Dianchi Lake in the Yunnan Province of China. A comparison was made between the proposed project and the current water hyacinth control measures.

The study site: Dianchi Lake

Dianchi Lake is situated south of Kunming City, the provincial capital of Yunnan Province. Due to the rapid development of the region's economy, the lake has been severely polluted for several decades. It is currently one of the most severely polluted lakes in China and one of three lakes given national priority for treatment. The lake is suffering from eutrophication, with COD, BOD, TN, TP and NH_3-N well above standard levels. As algae flourishes all over the lake, its aquatic system and biodiversity have been all but destroyed and the lake can no longer supply drinking water to the city. The city is now resorting to using Songhuaba reservoir for water.

The growth of water hyacinth is one of the lake's biggest problems. In the Dianchi watershed, the annual average growth of water hyacinth is around 250,000 tonnes in fresh weight. Over the past five years, a total of 820,000 tonnes of water hyacinth has been removed and disposed of as landfill. At present, there are eight working units designated by the Kunming municipal government to water hyacinth removal and disposal.

Using water hyacinth to produce biogas

The proposed biogas project would have two anaerobic digesters, with a combined volume of 700 m^3. One would be a high-temperature anaerobic digester, and the other a mid-temperature digester. Both would be heated by the solar thermal water system. Per cubic meter of digester stuffed with water hyacinth biomass slurry, the system can produce a daily yield of 1.5 m^3 and 1.0 m^3 of biogas from the two digesters, respectively. The proposed system would also include an organic fertilizer production system and supporting facilities, including buildings and a solar thermal water system. The plant would consume a total of 11,004.2 tonnes of water hyacinth (in fresh weight) every year.

Two methods were used to collect data for the study: field work and a review of relevant literature. The fieldwork involved travel to Dianchi Lake and its management agencies. Techno-economic data about biogas production was collected from an experimental biogas production plant in Jinning county of Kunming municipality. This is a demonstration project funded by the Yunnan Provincial Department of Science and Technology. Interviews were conducted with key people in the Dianchi Lake management office. Information on the growth of water hyacinth and its ability to absorb pollutants was collected from the Dianchi Management Bureau and related literature. Information on the cost of harvesting, transportation, and labor was obtained by interviewing workers and managerial staff at the Dianchi Management Bureau.

The biogas plant's performance

The study finds that the proposed biogas plant would cost around 13.52 million Yuan to construct and operate. The major elements of this cost would be: the cost of harvesting the water hyacinth, the investment necessary to build the plant, staff salaries, transportation costs, and electricity consumption.

The plant would have an annual output of biogas of around 245,438 litres, with an estimated value of 602,941 Yuan. The plant would also produce organic fertilizer with an estimated value of 210,000 Yuan a year. The total value of merchantable products (i.e., biogas and organic fertilizer) would account for 36.2% of

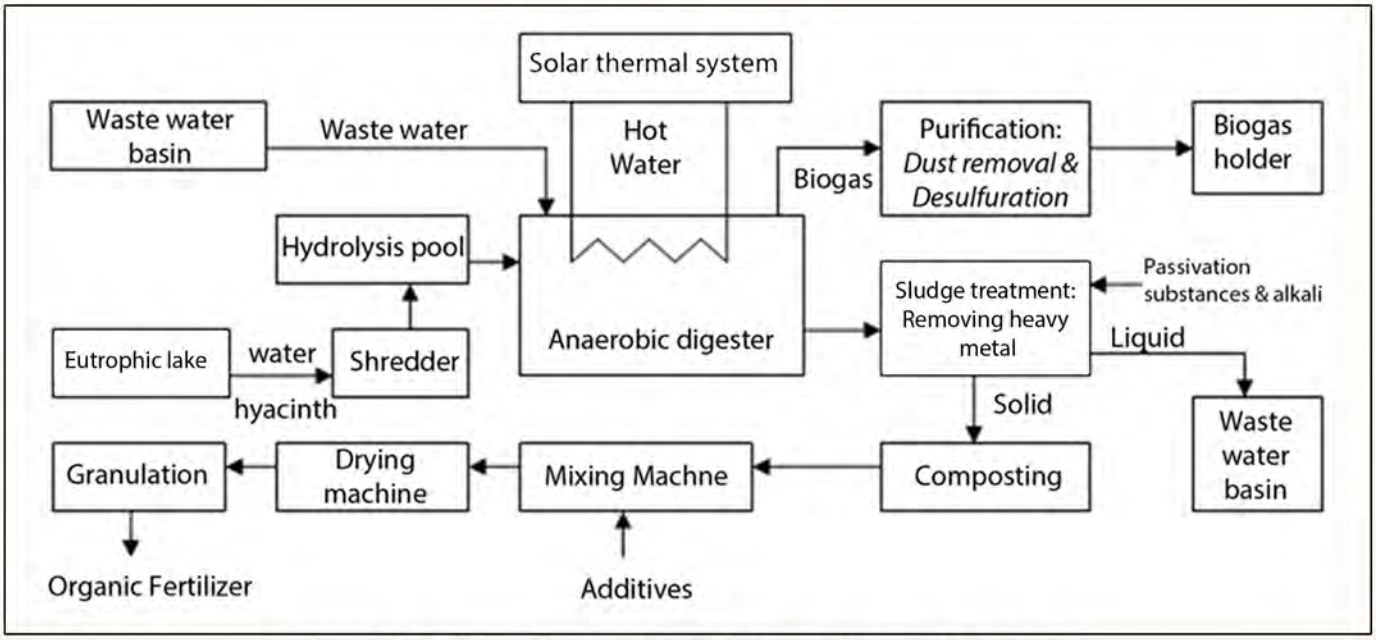

Figure 1. Producing biogas and organic fertilizer from water hyacinth

the total direct benefits produced by the plant. Its operation would also produce water quality improvements worth 1,332,581 Yuan a year. These would account for 59.3% of its total direct benefits.

Due to its contribution to greenhouse gas (GHG) emission reduction, the production of biogas from water hyacinth would be a potential Clean Development Mechanism (CDM) project. With an annual consumption of 11,004 tonnes of water hyacinth, the project could result in a reduction of 3,922 tonnes of CO_2-eq per year. The value of this emission reduction is estimated to be 0.36 million Yuan a year, given the market price of certified emission reduction (CER) in the CDM market in China in 2011.

Biogas plant: economically feasible

Despite these benefits, the plant would still cost more to run than it would generate in direct returns to its operator. However, if the wider benefits to society are taken into account, then the biogas plant would make good economic sense. If the biogas plant consumed 11,004 tonnes of water hyacinth per year, then it would have an overall net economic value of 13.14 million Yuan. What's more, the local government would spend less money on the control of water hyacinth if they were to implement the proposed project. Currently, the municipal government has to pay 105 Yuan per tonne to get water hyacinth disposed of; they would only pay 67 Yuan a tonne if the proposed project were implemented.

Compared with the proposed project, the results show that the current approach to controlling water hyacinth does not represent a good social investment and has an overall negative net economic value. One of the main problems with the current landfill approach is that as the water hyacinth decomposes in landfill it produces large amounts of methane emissions. The cost of these emissions is one of the key reasons why the current approach in dealing with water hyacinth has a negative net economic value. Indeed, if there is no biogas project and water hyacinth continues to be removed at the current average rate (i.e., 164,000 tonnes per year), the cost to society as a whole would be 21.16 million Yuan over 15 years.

How big should the biogas project be?

As the annual growth of water hyacinth in Dianchi Lake is around 250,000 tonnes, any biogas project on the lake could have a much larger capacity than that proposed. The study therefore looked at whether the project could be scaled up and how this would impact on its economic performance.

The study finds that, if the processing scale was less than or equal to the current amount of water hyacinth removed for landfill (i.e., 164,000 tonnes), then the project would generate no additional value through water quality improvements. However,

Table 1. Results of the economic analysis

Component	Without project (0) (million Yuan)	With project (1) (million Yuan)
Benefits		
Benefit of biogas		6.21 (26.84%)
Value of GHG emission reduction		0.47 (2.04%)
Benefit of organic fertilizer		2.16 (9.35%)
Value of water quality improvement	13.72	13.72 (59.31%)
Salvage value of fixed assets		0.56 (2.44%)
Costs		
The cost of collecting water hyacinth	4.25 (28.06%)	4.25 (37.27%)
Fixed cost (machinery and land rent)		3.14 (27.51%)
Workers' wages for disposing of water hyacinth	1.36 (8.98%)	2.22 (19.51%)
Cost of GHG emissions other than methane	0.02 (0.13%)	0.02 (0.14%)
Cost of methane emissions	6.04 (39.91%)	
Cost of transportation and landfill	3.47 (22.90%)	1.24 (10.89%)
Others (including land rent, electricity charges, repair and maintenance costs, payment for passivation substance and alkali)	0.002 (0.01%)	0.50 (4.38%)
Sub-total (C)	15.56 (100%)	11.40 (100%)
Economic gain (E(i)=B(i)-C(i))	-1.42	11.72
Economic Net Present Value (=E(1)-E(0))	13.14	

it would add value by further reducing the methane emissions produced by the current water hyacinth disposal practices. If the processing scale was greater than 164,000 tonnes, then the processing of each additional unit of water hyacinth would generate additional value by improving water quality. However, it would deliver no more additional gains linked to methane emission reductions.

Overall, the study recommends that the proposed biogas project is a good alternative to the current approach because methane emissions can be avoided and the biomass of water hyacinth is used rather than being simply disposed of as waste. Moreover, it finds that the project is desirable in terms of its energy performance and its overall economic performance.

A potential way forward for other lakes in China

These findings are very significant as the surface of most of China's major bodies of water have been severely polluted due to rapid economic development and a lack of environmental management. As the study provides a detailed picture of the costs and benefits involved in putting in place an integrated system to both control water hyacinth and produce biogas, it can serve as a reference for the remediation of other eutrophic bodies of water.

In addition, it is clear that the proposed project could provide a way for local governments to respond to China's national policies on water pollution control, renewable energy development, energy saving, and emission reductions. However, the study notes that a number of institutional arrangements would need to be put in place to coordinate, finance and drive the development of a network of such biogas plants.

The study concludes by highlighting various areas for further study, including the assessment of the most economic size of biogas plant. Moreover, as the possibility of using water hyacinth to clean a lake is affected by many factors, more work needs to be done to investigate the effects of harvesting water hyacinth on water pollution.

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