A CHINA ENVIRONMENTAL HEALTH PROJECT RESEARCH BRIEF

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Taihu: Green Wash or Green Clean?

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On May 28, 2007, residents of Wuxi discovered a new meaning to "going green" as foul-smelling green water flowed out of their taps. The primary water source for Wuxi is Lake Tai (Taihu), which had erupted in a toxic and noxious-smelling algae spurred by organic pollution, heat, and low rainfall. Wuxi City's two million residents could not access clean tap water for five days and frustration among residents rose.[1] By way of compensation, Wuxi municipal government reduced tap water prices by half for the month of June.[2] This major pollution incident occurred despite nearly a decade of central government investment to improve Taihu's water quality, yet this algae bloom sparked new initiatives aimed at getting beyond major environmental governance problems that drive poor enforcement of water pollution control laws in China.

IT'S NOT EASY BEING GREEN

Ignoring proper nouns the opening anecdote could easily describe a scene from any number of places including the shores of Lake Erie in the 1960s, 1970s, 1980s or even as recently as 1999 when toxic algal blooms from municipal and agricultural waste blanketed the western reaches of the lake. Even Taihu's "crisis" is but an extreme version of earlier blooms that date back to the 1980s, as summer heat and pollution mix in the shallow lake, creating ideal conditions for blue-green algae (cyanobacteria). Over the past decades China's three most polluted lakes—Taihu (3rd largest), Chaohu (5th largest), and Dianchi (6th largest)—have suffered from almost annual major blooms of cyanobacteria, bringing China's lakes into the international spotlight. A month after the Taihu bloom in 2007—particularly notable because it was a toxic species of cyanobacteria (microcystis)—a blue-green algae bloom swiftly covered one-third of the surface of Chaohu in Anhui Province.[3] According to a 2006 report by China's Ministry of Environment Protection, Chaohu's water quality received the worst possible score of five.[4] Yet that same year, the water quality score in Taihu and Dianchi was an even worse five-plus.

These dismal water quality reports occurred despite a series of government-launched clean up campaigns in these lakes. Over ten years, the central government dedicated 4.7 billion Yuan (about 0.6 billion dollars) to clean up Dianchi,[5] yet its water is no longer safe enough to supply drinking water for Yunnan's provincial capital, Kunming, and is now limited to agricultural use.[6]

In the summer of 2007, after physically removing more than 6,000 tons of algae from Taihu and protecting drinking water pipes with polyvinyl chloride (PVC) barriers,[7] additional short-term solutions ranged from inducing rainfall to diverting water from nearby rivers to flush out the bloom (with the Yangtze supplying both Chaohu[8] and Taihu[9]), and from adding algae-killing chemicals[10] to algae-eating fish spawn to the lake.[11] Ultimately however, it was winter that ended the massive 2007 bloom. Because central officials regarded local governments as partially responsible for the crisis, five local officials from Yixing (under the jurisdiction of Wuxi on Taihu) were demoted or dismissed for dereliction of duty.[12] After the algae was cleared, city leaders closed as many as 1,000 factories[13] and attempted to rebuild confidence by publicly drinking tap water to prove the return of safe drinking water.[14]

After a decade of central government investment, Taihu's tenacious algae blooms exemplify major shortcomings in water pollution governance in China. To reach the central government's goal of

completely restoring these lakes by 2030 and meeting the needs of agriculture, industry, and citizens for water, central officials have significantly strengthened the newly revised water pollution control law and funded pilot projects aimed at creating incentives for industries to lower emissions voluntarily and encouraged research to control algae blooms.[15]

TAIHU: THE JOLLY GREEN GIANT

The largest of China's three most polluted lakes, Taihu, is both a famous sightseeing destination and a prosperous economic region. However, the area's environmental infrastructure has been unable to keep pace with economic expansion and algae blooms have been reported annually since the early 1990s.[16] These blooms stem from emissions of nitrogen and phosphorus from three major sources: factories, municipal wastewater, and agriculture.

Factory Emissions

One of the main pillars of rapid growth and pollution in the Taihu watershed is the nearly 20,000 small-size chemical companies.[17] Nitrogen and phosphorus are common cleansing agents in industrial processes and are frequently released with wastewater from poorly monitored factories in China.[18] According to China's state media, the main industries responsible for Taihu's high chemical oxygen demand (COD)—an indirect measure of organic compounds in water—are the textile, chemical, and food processing industries.[19]

Factory emissions also affect the lake's water quality through air emissions. Taihu is a very shallow lake and largely dependent on rainwater for replenishment. In dry seasons the lake is particularly vulnerable to the nitrogen in acid rain that directly feeds cyanobacteria blooms near the water surface.[20] Further, many types of cyanobacteria—though not the main culprit in the 2007 blooms—can transform airborne nitrogen into fertilizer in a process called nitrogen fixing.[21]

Municipal Wastewater Emissions

Between 20 and 30 percent of eutrophication in Taihu is attributed to municipal sewage, according to a Nanjing Agricultural University study.[22] Hans Paerl, of the Institute for Marine Sciences at the University of North Carolina estimates that 50 percent of the nitrogen in the lake originates in municipal wastewater.[23] This is not surprising given that 33.5 million people live in the area surrounding the lake.[24] According to a Jiangsu provincial environmental protection bureau (EPB) document, there are 127 functioning sewage treatment plants around the Taihu watershed, with a combined capacity to treat 3 million tons of sewage water every day.[25] However, their actual treatment rate is 1.98 million tons, so clearly wastewater treatment plants around Taihu are not fully utilized.[26] Province-wide data shows that currently, less than 50 percent of the urban sewage in the lake's watershed is treated. Among the 127 facilities, 111 have installed dephosphorization and denitrification equipment, but they are not always well maintained or even turned on consistently.[27] The target of the 11th Five-Year Program is to increase the sewage treatment rate to 75 percent around the Taihu watershed by 2010.

Agricultural Emissions

Taihu is historically a very rich and fertile area and many types of farming are widespread. According to a Nanjing Agricultural University study, 60 percent of Taihu's organic pollution can be attributed to agriculture—40 percent of which originates from aquaculture.[28] This lake is most famous for hairy crab and its "three whites:" white shrimp, whitefish and whitebait. A 2007 figure indicated that 3 percent (100,000 *mu*) of Taihu's area was used for aquaculture, especially crab culture.[29] Land-based agriculture also has been a major contributor to Taihu's pollution particularly as farmers, fearful of counterfeit chemicals and paper thin profit margins over apply chemical fertilizer and pesticides.[30] According to a spokesman from China Academy of Science, industrial emissions of nitrogen and phosphorus are declining while those from municipal waste and agriculture are increasing.[31]

Impact of the Triple Threat on Human and Ecological Health

Heavy pollution from industry, municipal, and agricultural sectors have created a lake that is eutrophic—a condition resulting in low oxygen levels and often measured in COD—at a "medium level." Eutrophication results in loss of biodiversity as many creatures, particularly bottom dwellers, cannot withstand the low and fluctuating levels of oxygen. Algae prosper under these conditions when the water is warm. Toxic varieties of algae present a variety of threats to human health by damaging the liver, intestines, and nervous system.[32] Additionally, the toxins can accumulate in fish and shellfish, becoming dangerous to humans that eat those animals. Consuming water contaminated with toxic algae can lead to diarrhea and liver failure.[33]

GOVERNMENT INACTIONS, REACTIONS AND ACTIONS

Pollution in Taihu has been discussed at all levels of government and in the news for many years, yet the topic remains highly sensitive in China. In 2007, just a month before the algae bloom made international headlines, environmental activist Wu Lihong was arrested on potentially trumped up charges and later sentenced to 3 years in prison. According to a report by *The New York Times*, Wu Lihong had been reporting on the deleterious impacts of Taihu's chemical factories to the central and local governments from 1998 to 2006—sending 200 largely ignored reports of pollution incidents to the Jiangsu Environmental Protection Bureau during that time.[34] Although a headline maker, Wu Lihong was not an isolated case of Taihu pollution leading officials to make arrests. During the algae bloom, the local authorities arrested several people accused of spreading rumors that the tap water was carcinogenic.[35]

Although there are few comprehensive figures on the cost of algal blooms to the economy, it is reasonable to assume that the transportation—as sluice gates were closed to boats to prevent the algae's spread—fishing, and tourism industries were severely impacted by the 2007 bloom, which was present in the lake at varying degrees of severity from April to December.[36] Notably, the lake's water is becoming too polluted for industrial and agricultural use in some areas. Thus, the government has increasingly prioritized environmental protection and clean up, aiming to have the lake restored by 2030.

Local Regulations and Action

Jiangsu and Zhejiang provinces have enacted numerous regulations and launched a series of clean ups since 1996 to attack the worsening water quality in Taihu. After Wuxi suspended its water supply in 2007, the government of Jiangsu Province launched a five-year $14.5 million rehabilitation plan.[37] The bloom hastened a key policy change in 2007, when the Standing Committee of the Jiangsu Provincial People's Congress revised the 1996 *Regulation of Preventing Water Pollution in Lake Tai in Jiangsu Province*. Originally intended to strike a balance between ecology and economic development, the revised law adopted some more aggressive measures to deal with pollution problems in that it:

- Establishes the Regional Approval Restriction (*quyu xianpi*) system so that environmental impact assessment (EIA)—and thus major construction projects—approval will be suspended for regions that break the total pollutant cap;
- Strengthens the water quality monitoring system through total discharge caps, and national- and local-level monitoring stations, increased penalties for non-compliance, and inter-regional law enforcement;[38]
- Establishes the Drinking Water Protection Program, which includes a public notification mechanism and daily patrolling of drinking water sources; and,
- Clarifies the liability of water pollution.

In 2007, the Jiangsu provincial government enacted the *Working Plan of Water Pollution Prevention in Lake Tai in Jiangsu Province,* which aims to control the eutrophication in Taihu within five years and

clean up the lake in another 8 to 10 years. This working plan established a series of measures and targets and requires local governments to raise emission standards and stop approving projects in which the emission discharges exceed the total emission discharge control target for the area—important foundational measures for creating a water pollution emissions trading program. By the end of 2010, Jiangsu Province aims to decrease 32.5 percent of COD, 33.4 percent of ammonia-nitrogen, 30 percent of total nitrogen, and 30 percent of total phosphorus below 2006 levels, as well as reach a municipal sewage treatment rate of 90 percent.[39]

Industry. Chemical plants were required to install nitrogen and phosphorus removal facilities by the end of June 2008.[40] Chemical factories that fail to meet the new water emission standard risk suspension and will be shut down permanently if they still fail to meet the standard by the end of June 2008.[41] Jiangsu Province has targeted the heaviest polluting industries. Additionally, industry in Wuxi is required to recycle 78 percent of its water by 2010.[42]

Municipal Waste. To counteract residential waste, the government has begun to require nearby townships to affiliate with a water treatment plant and are forbidden from discharging untreated sewage into Taihu or rivers in the watershed.[43] Detergents with phosphorous also have been banned in Wuxi.[44]

Agriculture. Additional regulations at the local level are forcing a reduction of enclosed aquaculture areas. The Suzhou municipal government, for instance, reached an agreement with fishers to close 1,733 hectares of aquaculture areas in the western areas of Taihu. The State Council currently aims to eliminate 50 percent of fish farms in the eastern area of Lake Tai by the end of 2008 while those in other areas will be heavily regulated over the next three years.[45] According to *Science* magazine, the Wuxi municipal government will now ban chemical fertilizers and pesticides.[46]

Central Government Measures

In August 2008, the National Development and Reform Commission issued a report on water management in the Taihu watershed. This report laid out plans to accelerate research and implement policies that would reduce eutrophication significantly in Taihu and increase the quality of the water by one grade level in all areas of the lake by 2012. The report prioritized the goal of increasing the quality to grade three around drinking water intakes.[47]

The Crucial Science and Technology Program of the National Water Pollution Control and Treatment Plan, from 2006 to 2010, also deemed Taihu one of the most important watersheds to research. Under this program, a series of technologies and environmental policies will be studied and piloted at Taihu, including issuing emission permits and adopting eutrophication mitigation technology. This program is a small part of the National Outline for Medium- and Long-Term Scientific and Technological Development, headed by the Ministry Science and Technology, which includes other topics such as public security and national defense.[48] To date, many of the details of the pilot projects on Taihu are not clear to many stakeholders, although Taihu expert Jun Bi from Nanjing University believes that details will be available soon.[49]

According to the Jiangsu government website, the Ministry of Finance and the Ministry of Environmental Protection approved a water trading pilot program in the Jiangsu part of the Taihu watershed in late 2007. In the first stage of the trial program—being orchestrated by Nanjing University—the pilot will issue and charge for COD discharge permits. The Jiangsu bureaus of environmental protection and finance will determine the COD discharge fee on the basis of clean up costs and other factors such as environmental carrying capacity and levels of economic development in different parts of the watershed. During the second phase, provincial agencies will create an open market for companies to buy and sell their COD discharge quotas. This will give companies incentives to reduce their organic pollution levels as they can sell the quotas they do not use. The trial

program will include the automatic monitoring of water quality, supervision of emitters, and the design of additional supporting programs. The trial program will soon expand to include the entire Taihu watershed.[50]

International Initiatives
The World Bank provided a loan of $61.3 million to China for the Lake Tai Basin Urban Environment Project in 2004. The project aims to increase the capture and treatment of wastewater in key cities in the basin and their suburban districts through investments and institutional and financial reforms. The project supports rehabilitation and water quality improvement in several urban and district canal and river systems through investments and improved water management. It also supports lakeshore rehabilitation around Wuli Lake as a new development and amenity area for Wuxi. The project seeks to strengthen water resource protection in the Taihu watershed through improved and integrated planning, water quality monitoring, and environmental management.[51]

WWF-China, in an alliance with beverage giant Diageo, initiated the Protecting the Water Source in East Lake Tai Project in November 2007. This two-plus year project aims to improve the quality of the regional water supply, ensure flood control, as well as preserve local biodiversity in the eastern part of Taihu—the most heavily industrialized part of the watershed.[52]

Hans Paerl of the University of North Carolina is working with the Nanjing Institute for Geography and Limnology of the Chinese Academy of Social Sciences on a three-year project funded by the U.S. National Science Foundation that was launched in September 2008. This project will apply existing technology that was used to assess nutrient overload in the United States and Europe to Taihu in order to analyze what conditions cause the blooms and what conditions make them dissipate. The team will also analyze the cyanobacteria itself to see how similar it is to other studied cyanobacteria globally in terms of toxicity and speed of growth.[53]

CLEANING THE GREEN
Cyanobacteria, or blue-green algae, is a threat to ecology and human health around many major lakes globally—including Lake Victoria and Lake Erie—and is notably exacerbated by reduced rainfall and higher temperatures associated with climate change. Thus, it is a perfect area for international cooperation on a much greater scale than is currently occurring. One key for China to successfully combat future and intensifying blooms will be for its scientists and policymakers to work closely with counterparts in countries that have been combating such blooms for some time, such as the United States, and learn from their mistakes. For example, in the United States, emphasis has traditionally been placed on reducing phosphorus—particularly from detergents—yet blooms continued because the nitrogen element was not addressed.[54]

Chinese studies indicate that approximately 50 percent of nitrogen and phosphorus in the Taihu are from point source pollution, which Hans Paerl believes are accurate estimates. The good news is that these pollutants are very easily controlled. Paerl recommends three central steps towards a cleaner Taihu:

(1) Target point sources by treating all wastewater for nitrogen and phosphorus;
(2) Reduce agricultural fertilizer runoff by teaching farmers to apply fertilizers only when, where and in the quantity needed—a step that particularly lends itself to international cooperation as industrialized countries continue to struggle in this area; and,
(3) Address atmospheric deposition of nitrogen and phosphorus upon the water and within the watershed.

This last recommendation is the most challenging and probably demands a national "Clean Air Act" equivalent, as enforcement will reach beyond Jiangsu Province and involve many sectors including

the transportation, industrial, and agricultural.[55] Paerl emphasized that nitrogen and phosphorus must be controlled in a balanced way, for if nitrogen is reduced faster than phosphorus, the dominant algae on the lake could switch to another species such as anabaena, another toxic variety that supplement waterborne nutrients by fixing airborne nitrogen.[56] Long-term success on all policy and scientific initiatives depends on a sustained commitment from local officials to provide finances and quality data, which have been central challenges for Taihu and other major water clean up projects in China.

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