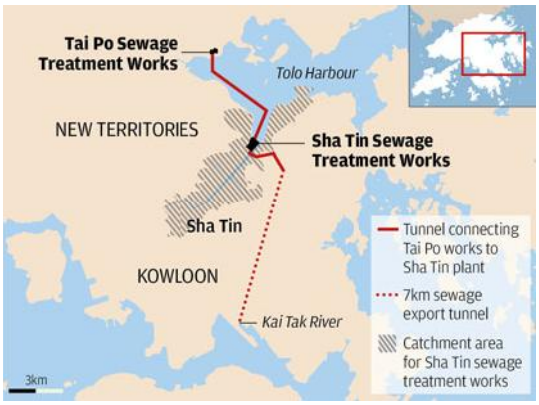
By Christy Choi

Beneath the city's skin, behind its walls and under the concrete runs a labyrinth of pipes and tunnels. These are the lifeline of Hong Kong's waste-water treatment works; veins and arteries of a mammoth undertaking that cleans the water.

"2.9 million cubic metres," said Edmond Ho Wai-kwong, the senior engineer at the Shatin Sewage Treatment Works. That's the amount of waste water that's treated in Hong Kong every day – enough to fill 1,160 Olympic-sized pools.

In the past, it was just organic matter and pathogens that most worried those caring for our water, but our obsessions with health, cleanliness, personal care and the advances in sanitation and medicine have added other hazards.



LAY OF THE LAND: The Shatin Sewage Treatment Works and the area it serves. To keep Tolo Harbour clean of pollutants, effluent from the Tai Po and Shatin Sewage Works is pumped through a tunnel that stretches over several kilometres to Kai Tak River and ultimately Victoria Harbour. (Source: Sha Tin Sewage Treatment Works)

Swimming in our waste water is a mix of bacteria, human hormones, chemicals that mimic hormones, half-processed drugs and antibiotics, detergents, sunscreen, as well as urine, faeces and the little organic remnants of meals washed down when you do the dishes, all from the 7.7 million inhabitants and visitors to the city.

This cocktail of chemicals and organic matter, if released straight into the ocean, is bad news, especially for areas where the water stays for days before exchanging and circulating with the wider seas.

"Before the treatment works were built, Tolo Harbour was a dead zone," said Kenneth Leung Mei-yee, associate professor at University of Hong Kong's school of biological sciences. Leung is an expert in marine toxicology who studies the effects of chemicals found in laundry detergent, sunscreen and other substances we use in our day-to-day lives.

Before the late 1990s, the problem for Tolo Harbour was run-off from the pig farms entering the waterways. A potent fertiliser of faeces and urine contaminated the water and caused frequent algal blooms which used up the dissolved oxygen in the water and then died off, only to deplete the oxygen levels even more as bacteria took over to digest their carcasses. Without dissolved oxygen, most life stops in the oceans.

The pig farms are gone now, replaced with new towns home to around 650,000 people whose excreta is just as potent as that of the pigs. And, of course, all the chemicals of modern convenience and personal care, which do more than keep us clean and make us pretty.

"Before the treatment works were built Tolo Harbour was a dead zone."

"The effects of nonylphenols have been well-documented to show that they can change the sex of fish," said Leung. Found in some detergents, pesticides, cleaning agents and cosmetics, nonylphenols are chemicals which mimic the hormone oestrogen. In high enough concentrations, they trigger gender changes by changing the balance of hormones in the bodies of fish, frogs and other organisms.

Scientists studying polluted areas of the Colorado River in the United States have found anti-depressant medication concentrated in the brains of fish, while Rebecca Kalper, an ecologist at the University of Wisconsin-Madison, found a chemical in the drug Prozac made male fathead minnows, a common US freshwater fish, stop reproducing and behave aggressively, even killing female minnows, while larvae exposed to a chemical found in birth-control pills, 17β-estradiol, found it harder to avoid predators.

There's also the matter of the antibiotics that Hong Kong doctors are so prone to giving out. Between 80 and 90 per cent of antibiotics we consume pass through the body without being broken down and end up in our waste water, allowing bacteria to develop resistance to life-saving antibiotics, according to the Alliance for the Prudent Use of Antibiotics at Tufts University in Boston.

POTENT MIX: Detergents, antibiotics, birth control pills, and more...these chemicals found in a typical Hong Kong flat might improve our quality of life, but come at a cost to the environment.

In Hong Kong it's hard to say what the impact has been. The few studies are inconclusive, with some showing results that are detrimental and others that there is no effect, says Professor Rudolf Wu Shiu-sun, director of HKU's school of biological sciences. "What's clear is that [chemicals are] all around."

But the effect, he says, would be much worse without primary treatment, in particular at the Sha Tin Treatment Works which can filter out between 50 and 90 per cent of most chemicals before they hit the water. And they're helped by unlikely allies.

"Amoeba, protozoa, tiny worms, bacteria, they're all in there," said Sammy Lee, the plant's resident chemist pointing to the murky grey water swilling about, bubbling, popping in the open-air aeration tank about the size of a small swimming pool. Lee stands at the fringes of the 28-hectare plant just off Tate's Cairn Highway, overlooking the once polluted Tolo Harbour. Life has returned to the dead zone, because of these micro-organisms that change the chemicals into their less harmful parts – nitrogen, carbon dioxide, and other basic elements.

Oxygen is pumped into the tank to encourage micro-organisms to multiply and eat away at the waste in the water. The balance is delicate, with temperature, oxygen levels, salinity and other factors altering the microbial ecology.

If the temperature is too low or there is not enough oxygen, the organisms that help the process begin to die off and the sewage starts to smell bad and produce an unsightly foam. It's a bit of an art getting the balance right, says Ho. "Plans are important, but experience is more so," he said.

HOW IT WORKS: Secondary Treatment at the Sha Tin Sewage Treatment Works

The team takes samples from the different tanks, around the clock, several times a day, to monitor how well the organisms are removing suspended solids, nutrients, toxic substances and inorganic nitrogen, among others.

On this summer day, the smell in the air is a little acerbic like the smell of a high school chemistry lab, but not the full-on assault on the nostrils prompted by raw sewage. "That's a healthy smell," Ho says.

The Sha Tin plant is able to clean up to 90 per cent of pollutants from the roughly 260,000 cubic metres of water it treats every day. But only 17 per cent of Hong Kong's sewage goes through this kind of secondary treatment.

Almost all of the rest is either simply screened or chemically treated to remove sludge and kill pathogens before being released in the surrounding seas by submarine outfalls. The bulk of it ends up in Victoria Harbour, flushed out by the Stonecutters Island Treatment Works at West Kowloon.

Unlike Tolo Harbour, Victoria Harbour's constant flows of fresh seawater in and out of the channels makes the possibility of pollutants accumulating in problematically high concentrations unlikely, Leung says. But he cautions that there could be cumulative effects in other areas around the Pearl River Delta that have yet to be recorded.

With this possibility in mind, the government has for over a decade considered turning the Stonecutters Island facility into a secondary treatment plant like Sha Tin, as part of Stage 2B of the Harbour Area Treatment Scheme.

Stage 2A is linking up more of the current network to the existing Stonecutters Island plant to reduce the amount of raw sewage that makes it into the water. Currently around 30 per cent of Hong Kong's waste water is released without chemical or biological treatment.

There are even ways to turn waste water into pristine, drinkable water.

"It all depends on how much you are willing to spend," says Professor Chen Guanghao of the Hong Kong University of Science and Technology. "The technology is there."

"It'll be several hundred years before we change our ways."

In 2008, it cost around HK$1.2 billion to provide sewage services to the city. The Environmental Protection Department estimates the cost of secondary treatment to be about four to five times higher than primary treatment. And the cost of reverse-osmosis, which filters the water into pristine condition, is even higher. "It's not affordable," says Wu. He was unable to give a figure for how much it would cost.

But even if the science is there, the crux of the issue is human consumption and the habits of the city. "It'll be several hundred years before we change our ways," Leung says.

"I did a simple experiment with 120 students," he said. "Put a little sesame oil on their fingers and, once cleaned with detergent, another time with ordinary soap ... they all said they'd rather use the detergent, it took longer with the soap.

"Even after I told them the effects of what happens to the environment, they said: 'We'll try and use soap when we have time, but if we're in a hurry, the detergent is better'."

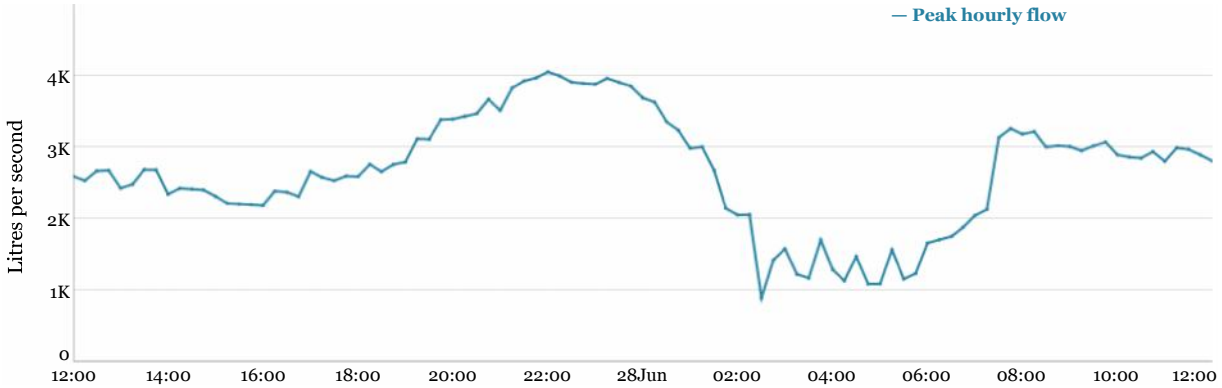
The rest of the water needed in Hong Kong is shipped in from Guangdong province through massive pipes that start at a tributary of the Dongjiang, or East River. But there may be competition soon, as the mainland's continuing urbanisation puts stress on water resources.

“Hong Kong only has around 125-150 cubic metres of fresh water capacity per person [each year],” says Chen Guanghao, a professor of civil engineering at the Hong Kong University of Science and Technology.

The UN Food and Agriculture Organisation says that 500 cubic metres per person per year is the bare minimum needed. North Africa and the Middle East all hover around the 1,100 cubic metres mark, according to a 2007 report by the World Bank.

Hong Kong is not alone in its predicament. The Beijing government has started the first phase of an ambitious and controversial 50-year project that will divert freshwater from the southern provinces to the more arid north, as the rapid growth of Beijing and other cities means there is less water to go around.

Even as China’s water consumption rises, climate scientists are warning of the fast retreat of glaciers in the Himalayas and the Tibetan Plateau, which feed the Yangtze, Yellow and Mekong rivers. The glaciers supply water to about 1.4 billion people in Asia, and have shrunk by 9 per cent in the past 30 years, according to data published last year in the journal Nature Climate Change.



WHEN DO WE USE THE MOST WATER? Daily sewage flow into the Shatin Treatment Works. Select an area to zoom in.

To help Asia deal with this looming water crisis, Chen and his colleague Dr Samuel Chui have a solution that would greatly reduce urban consumption of the precious resource. It’s a three-part water conservation and treatment system that will also reduce energy usage and carbon dioxide emissions, and produce a phosphorous-based fertiliser called struvite.

Chek Lap Kok airport has already been using one part of the Chen and Chui’s water strategy water-saving plans since the mid-1990s. The Triple Water Supply system has allowed the airport to halve its freshwater demand, save 30,000 MWh of energy and reduce its carbon-dioxide output by 17,000 tonnes.

The key is using seawater and reusing and recycling grey water, the dirty freshwater from people washing their hands and doing their dishes. The seawater cools buildings and is used to flush toilets. The dirty freshwater gets treated and is then used to irrigate grass and clean the outside of aircraft and other surfaces that people don’t normally touch.

Just a few minutes away in the new town of Tung Chung, the second part of the equation is in action. Sewage sludge is being digested by several different colonies of slow-growing bacteria, which convert the sewage into harmless sulphates, nitrogen and carbon dioxide.

Chui points to a trial run of the process at a small plant in Tung Chung, which has been treating around 10 cubic metres of sewage a day for months.

The system, he said, is guaranteed to eliminate about 90 per cent of the sludge, but can be even more effective, and that the Tung Chung plant has accounted for virtually all the sewage fed into it for 225 days.

Hong Kong produces around 1,150 tonnes of sewage sludge daily. Thick crumbly truckloads are carted away from Hong Kong’s waste water treatment facilities to landfills, and mixed in with the 13,500 tonnes of discarded plastic bottles, construction waste and other detritus of city life generated each day. With space in the city’s three landfills set to run out within the next decade, Hong Kong is looking to reduce the amount of waste that is dumped each day.

A larger plant able to treat 1,000 cubic metres of sewage a day is being built in Sha Tin. The project, costing HK$24.5 million, is expected to begin trials in 2015.

The Drainage Services Department promised wide-scale implementation across Hong Kong if the plant is successful, HKUST’s school of engineering says.

The final part of the water strategy is a process that converts phosphorus in urine to fertiliser, by adding one part hydrolysed urine to one part seawater. With the help of bacteria in the seawater, magnesium in the seawater reacts with ammonia to create the struvite within 15 minutes.

“It doesn’t need energy, or the addition of expensive chemicals. All the elements needed are already in the seawater,” Chen said.

The process could also recover 30,000 tonnes of phosphorus, worth around US$150 million. Phosphorus is an essential nutrient, necessary for the creation of DNA, cell membranes, and for bone and teeth formation in humans, and also a vital part of commercial fertilisers that are currently in use.

“We’re going from bad pee to good P.”

But it is in our interests to keep phosphorus from being washed back into the ocean. Like nitrates, phosphorus can cause harmful algal blooms that over time cause dead zones in coastal areas by depleting the amount of dissolved oxygen in the water.

These dead zones are a growing problem in coastal areas worldwide. In 2008, there were 405 of them recorded, up from 162 in the 1980s and 49 in the 1960s.

“We’re going from bad pee to good P,” Chen said, referring to the chemical symbol for phosphorus.

Were 120 million people to adopt the integrated water strategy, it could save 4.7 billion cubic metres of freshwater and US$450 million per year.

It would also eliminate 10 million tonnes of sludge and save US$290 million in incineration costs, according to an article by Chen and his colleagues in Water21, the magazine of the International Water Association.

The final stop for the water we use, **VICTORIA HARBOUR**.

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