# Waiting for a swim – handling wastewater in Asia

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**As Pattaya, Thailand, grew into a major tourist resort, its coastal water quality deteriorated rapidly and the tourists began to leave. A computer model has been used to predict the combined effects of the sewer system, the wastewater treatment plant and the behaviour of the coastal waters on water quality.**

As the cities of Asia grow rapidly, it is very important that attention is paid to their handling of wastewater. The water infrastructure – supply networks, sewerage systems, purification and wastewater treatment plants – affects the daily lives of millions of people. Many of the cities are old, and they have developed to fulfil historical needs and visions. The layout and design of the infrastructure have gradually developed into complex systems. To bring about the necessary changes in management strategies requires knowledge about the full system and tools that can handle such systems, together with an understanding of the biological impacts on the eco-system.

**'Pattaya has moved too quickly from being a small fishing village to a big city with a high level of tourism'**

## Handling wastewater in Asia

This is a challenge for nearly all countries in Asia. At present, there is no clear overview in Asia about the actual amount and quality of untreated wastewater used on the fields, and where this wastewater originates. To quote the International Water Management Institute:

> In developing countries, wastewater irrigation offers equally important advantages and dangers to people's health and the environment. Whatever the perceptions, the simple truth is: in these countries, wastewater irrigation is a fact of life.[1]

So it is common practice to use untreated wastewater, including urban wastewater, for irrigation and as an important source of nutrients to the fields. In many areas there is little control over the quality of the wastewater and therefore some unintentional health risks and pollution may arise. Wastewater from industrial areas, for example, may give rise to high levels of phosphorus or long-term heavy metal pollution. In addition, urban wastewater may contain high levels of bacteria such as *E. coli* and oocytes like *Giardia* and *Cryptosporidium,* as well as other parasite eggs. These are a direct health risk for the farmers using the wastewater on the fields – and may also be a risk for consumers of farm products. The treatment of wastewater prior to its use in irrigation may not always be a perfect solution either, since salinity may increase during the treatment to levels which reduce crop production.

The most frequent way of disposing of wastewater is simply to channel it directly into a river or the sea. If the quantity of wastewater is small compared to the natural treatment capacity of the receiving waters, this method of disposal may not be as bad as it sounds at first. But if natural wetlands are removed – as has happened in Vientiane, Lao PDR – in order to reduce flooding frequencies, then serious biological problems may occur and a pleasant aquatic environment may turn into a black, foul-smelling stream.

A heavily polluted stream in Vientiane, Lao PDR

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On the right, the combined sewer overflow discharges wastewater onto the beach after heavy rainfall

## Modelling urban pollution at Pattaya Beach

For the planning and management of urban water resources to be effective, it is essential to understand the physical system and its interaction with the environment. Computer models can be used to provide well-structured analyses of wastewater disposal. In the case of Pattaya Beach, models are used to provide a consistent analysis of problems in past and current situations. However, it must be emphasized that the application of models on their own does not solve the problem – combating pollution should start with education, source control and public awareness. People not only need a higher standard of living but also a clean environment – not only for themselves but also for future generations.

Coastal areas are sensitive, and often at risk from degradation. In some parts of the world, the coastal areas are so polluted that it is risky to swim from the beach; sewer outfalls discharging directly into the sea are often the cause of this pollution.

Pattaya is one such example that has moved too quickly from being a small fishing village to a big city with a high level of tourism. The environment of Pattaya beach and especially the water quality have been damaged, and this is the result of hotels, resorts and industrial factories discharging wastewater into the coastal water. The quality of the water at Pattaya beach has been identified by the Pollution Control Department as not suitable for swimming at certain times of the year. The highest numbers of coliform bacteria found at the sampling stations along Pattaya beach increased from 6000 MPN/100ml in 1976 to 11 000 MPN/100ml, 118 000 MPN/100ml and 240 000 MPN/100ml in 1978, 1984 and 1986 respectively (MPN means most probable number).[2] The Thai Environmental Protection Agency sets the recommended maximum value for coliforms in seawater at 1000 MPN/100ml.

Even though the new wastewater treatment plant has been operating since November 2000, the issue is still serious. Reports from the Tourism Organization of Thailand show that the number of tourists is declining day by day and the tourism industry at Pattaya has been seriously affected. At the time of writing, the wastewater treatment plant (WWTP) has a capacity of 65 000 $m^3$/day and it is planned to increase this to 137 500 $m^3$/day in the next 10 years. The question on everyone's lips is: 'what is the impact of the WWTP? And is it safe to swim in the waters at Pattaya?'

Since the WWTP commenced operations, the pollution levels have definitely decreased. The existing sewer system in Pattaya is a combined sewer system and serves 80 per cent of the city area. The closed sewers are designed for a return period of 5 years, and 10 years for open channels (i.e. there is a once in five years probability of the flow rate being beyond the capacity of the closed sewer). The system has two main pumping stations at the end of the pipe system and seven weirs discharging a mixture of sewage and rainwater directly onto the beach when the rainfall is more than approximately 20 mm (usually within one hour). This operational strategy has been chosen to prevent flooding inside the city area and this management objective has the first priority.

Models of the sewer system and coastal areas of Pattaya have been designed to provide an overview of how much the WWTP has improved the water quality at the beach and what the water quality is predicted to be in 10 years when the WWTP is operating at its maximum capacity. The study currently under way at AIT (Asian Institute of Technology) aims to describe conditions at Pattaya based on an analysis of the interaction between the urban drainage system, the wastewater treatment plant and the receiving waters, by use of integrated modelling. The following computer models from the company DHI Water & Environment are used: MOUSE TRAP for the drainage system,[3] MIKE 21 for the dilution of water discharged and the seawater, and a historical description of input and output water quality from the WWTP.

The aim of the present work is:

- to come up with a systematic evalua-

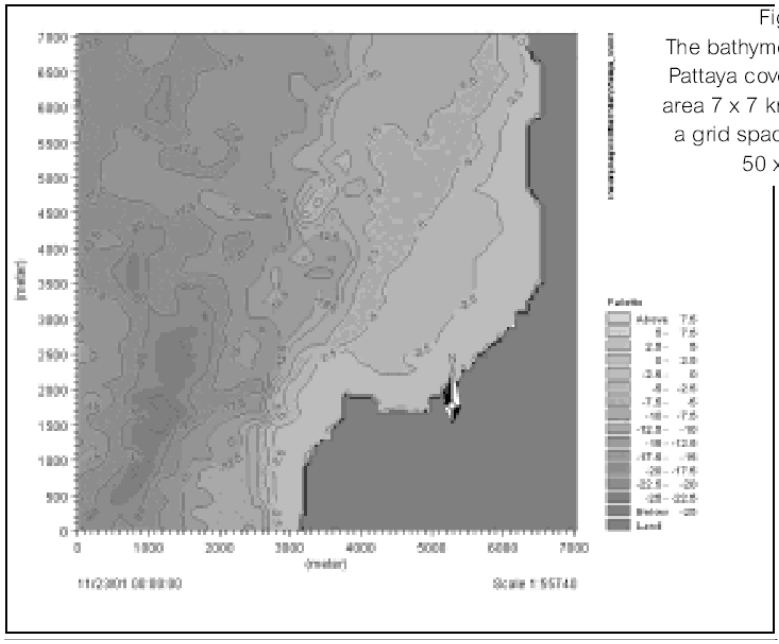

Figure 1
The bathymetry of Pattaya covers an area 7 x 7 km with a grid spacing of 50 x 50 m

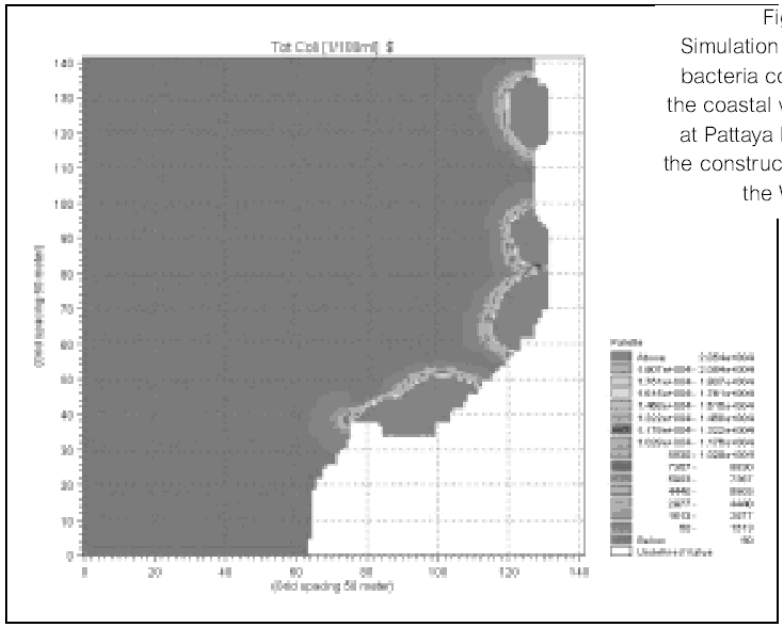

Figure 2
Simulation of the bacteria count in the coastal waters at Pattaya before the construction of the WWTP

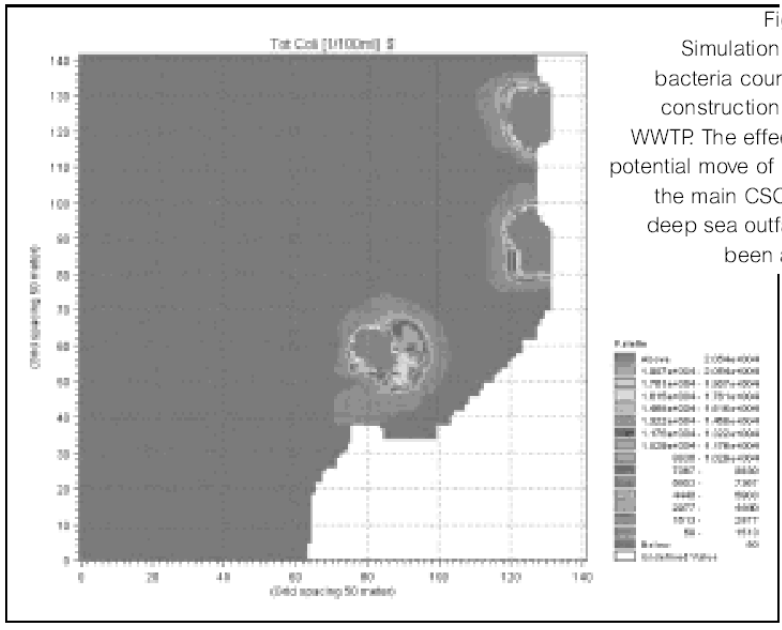

Figure 3
Simulation of the bacteria count after construction of the WWTP. The effect of a potential move of one of the main CSOs to a deep sea outfall has been added

tion of the water quality condition in Pattaya beach
- to quantify the impact of the construction of the wastewater treatment plant
- to analyse alternative schemes to find the optimum operation of the whole system.

## Modelling water quality at Pattaya beach

The hydrological and hydrodynamic MOUSE™ model has been set up based on the database from the Pollution Control Department. The modelling of pollutants is carried out by using an advection–dispersion model in the sewers, i.e. assuming the bacteria to act as a conservation pollutant (one which does not undergo a chemical or biological change). This assumption is fair as the concentration time in the Pattaya's sewer system is rather short. For the coastal waters it was decided to use only the 'Total Coliform' indicator, with a die-off rate as a function of salinity and time.

The bathymetry (average water depth) of Pattaya beach was constructed based on data from the Pattaya City Rehabilitation and Development Project, Chonburi Province. It is clear from Figure 1 that water off Pattaya Beach is quite shallow and confined, and therefore slower to disperse pollutants discharged into it. The results of MOUSE TRAP™ are applied as input for the WWTP, which is considered to be a black box. Measured output from the WWTP is used as input, together with the CSO (combined sewer overflow), for the MIKE 21™ model. The MIKE 21™ model was set up to run with the time of simulation as half a day (12 hrs) after the start of 'typical monsoon boundary conditions', meaning that flow along the coast should correspond to the most critical conditions.

In Figure 2, the areas of high concentration are caused by the overflows at those points: as the beach is confined and shallow there are very high concentrations of pollution along the beach. The deep sea outfall modelled in Figure 3 effectively moves the major CSO and the pollution away from the beach into the deeper part, which gives a higher dispersion and lower concentrations of pollution in the beach area.

## Perspectives for the future

It is necessary to understand the physical system and its interaction with the envi-

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ronment if effective planning and management of urban water resources is to occur. In this context, computer models allow for well-structured analyses of wastewater disposal and they offer a sound scientific framework for coordinated management and planning. Apart from allowing different scenarios to be assessed, these models also help improve process understanding.

The case study in this article describes the interaction between three parts of the sewer system during a CSO event: the sewer system state, WWTP response and seawater behaviour. The results from the models show that water quality off Pattaya beach has been improved significantly since the WWTP came into operation. The water near the coast is now considered suitable for swimming – if it has been some time since the last heavy rain. Further studies are currently being carried out to analyse different alleviation schemes to find the optimum operation of the drainage system, e.g. by use of real time control.

Dealing with wastewater involves not one problem, but a group of strongly interrelated problems which have major impacts on the people of Asia. Because of this, the authors are researching integration of the use of classical modelling tools related to water with an understanding of the biological and socio-economic impact of changing the management strategies currently adopted in Asian cities. The research and the modelling should be kept generic, so it should be easily possible to adopt the methodology for other similar cases of wastewater handling. It is our belief that the potential benefits of such approaches are enormous. Then, if you still have doubts about the water quality at your favourite resort after a heavy rain – just lie down and relax on the beautiful beach and wait a day or so before you go swimming.

## References

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