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## **In-situ Bio-Stimulation for Surface Water Restoration Using Biofeed® Products**

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### **Abstract**

While the traditional engineering disciplines feverishly look for means to control point and nonpoint sources surrounding our water environment, in-situ biostimulation offers an economical and practical solution to many water pollution problems at hand. In-situ biostimulation is a probiotic approach through which enzymes and stimulants are used to accelerate the breakdown and digestion of pollutants in the water column and the sediment by certain indigenous microorganisms in the environment. This paper reports the results of applying particular enzyme and nutrient-based biostimulant products to restore the urban water in Taipei County, Taiwan. The known ingredient of the product, the maker's explanation of the reasons why the product works, and the restoration results are given.

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### **Present Water Pollution Control Mindset and Its Dilemma**

When human activities and industries dump wastes into their surrounding waters at rate faster than what the decomposers in these waters can breakdown and digest the wastes, water pollution occurs.

Fundamental solutions to water pollution are (1) to control the amount and the rate the pollutants enter the waters and (2) to restore and/or enhance the waters' inherent capability to assimilate the wastes. The present environmental and water resources engineering communities have been focusing too much on the first approach and ignoring the second alternative for too long.

Methods to prevent (or limit) pollutants from entering the waters are sewage interceptors, sewer lines, and various levels of wastewater treatment. These methods require tremendous amount of resources and land which most densely populated and under-developed regions simply cannot afford. Because these control measures cost so much, the inhabitants of the affected regions have learned to live with pitch-black and obnoxiously odorous waters around them and wait in decades for the facilities to be properly built and operated. While they wait helplessly, the pollution continues (and worsens in most cases) and the price of pollution control climbs higher and higher. Will we ever be able to catch up?

### **In-situ Bio-stimulation Restoration**

In-situ water restoration refers to all methods or techniques which can restore and/or enhance given waters' inherent capability to assimilate or remove unwanted pollutants on site and thereby temporarily or permanently remediate the polluting condition. Some of the widely practiced in-situ restoration techniques include mechanical aeration, chemical oxidation, phyto-remediation, and certain wetland treatment systems. Sediment capping and dredging can also be loosely categorized as physical means of in-situ water restoration.

In-situ bio-stimulation is an on-site restoration technology which uses certain materials to stimulate the biosphere's indigenous capability to digest and remove unwanted pollutants. Unlike bio-augmentation in which foreign microorganisms, plants, or animals are added to the environment, bio-stimulation only introduces specific enzymes and nutrients to speed up the breakdown and digestion of organic wastes by the plants, animals, and microorganisms in the system.

The specific in-situ bio-stimulation technology reported here uses products derived from specialized organic products manufacturing. With highly developed carbon complexes and enzymatic systems as the base material, the liquid mixed products, originally made as natural organic fertilizers and soil conditioners, were found also very effective in "removing" organic wastes in certain polluted waters and their sediments. The original maker claimed that the enzymes in the various organic acids (organic acid, amino acid, and others) and the numerous forms of macro- and micro-nutrients can stimulate the digestive capability of particular microorganisms, thereby accelerate the degradation of most organic wastes in the water and sediment but the exact ingredients and compositions are closely guarded by the maker(s).

Due largely to these earlier practitioners' inability (or unwillingness) to publish such astonishing phenomena in related scientific journals or forums and to some extent, that the "discovery" did not come from disciplined research or standard texts, this promising water pollution control alternative is virtually unknown to most environmental and water resources engineers and regulatory agencies. Those who did come across the idea or efforts rarely showed any interest in it. It was not until recently that results of using biochemical fulvic acid and certain vegetable lixivium to reduce chemical oxygen demand and ammonia nitrogen in polluted waters in China have been published (Xu, et al., 2002; Fang, et al., 2005; and Fang, et al., 2005). The use of simple kiln dust, molasses, and alcohol to successfully restore acid mine drainage was also reported in the U.S. (Landers, 2006).

Since first exposed to the products eight years ago, the authors and their co-workers have conducted several experiments in the laboratories and selected polluted waters to examine their effectiveness. Barring uncontrollable perturbations, the products were found to be capable of effectively reducing 5-day biochemical oxygen demand ( $BOD_5$ ), ammonia-nitrogen ( $NH_3-N$ ), chemical oxygen demand (COD), and turbidity while increasing the dissolved oxygen (DO) in all waters tested (Chu, 2002; Chu and Lu, 2004). The remainder of this paper reports a most recent field application of the same products to another severely polluted water body in Taipei County, Taiwan.

### **The Polluted Water**

The restored water reported here is located within the Er-chung Floodway (the Floodway) on the Tanshui River floodplain between Taipei County and Taipei City in Taiwan (Fig.1). Left by receding floods and served as the receiver of the surrounding point and non-point pollution, the Floodway is covered with "pockets" of heavily polluted waters that adversely affect the scenic and recreational value of the various parks and bicycle trails in it. Funded by the Environmental Protection Administration (the EPA), an in-situ restoration of two designated waters in the Floodway was publicly tendered by Taipei County government in 2003. Environmental & Infrastructural Technologies, Inc. (EITCO) won the competitive bid to restore these waters in the second half of 2003.

One of the designated waters to be restored lies near Luti Park in the Floodway, which is conveniently called the No Name Creek in this study. The No Name Creek (the Creek) is approximately 700 meter long, 90 meter wide in the center, and with an averaged depth of 2.5 meter (Fig.1). Connected through culverts with other waters, the averaged volume of the Creek is approximately  $19,700\text{ m}^3$ . Detail channel geometry and bottom sludge and sediment thickness were obtained by survey done in five cross-sections (Figs.2 and 3) before the restoration in mid August, 2003. From the survey data and through linear interpolation, it was found that the bed of the No Name Creek was covered by approximately  $16,600\text{ m}^3$  of bottom sludge and sediment. Selected water quality indices taken from two sampling stations (identified in Fig.1) before the restoration are shown in the first column of Table 1. Before the treatment started, dissolved oxygen stayed consistently below 0.5 mg/L in most of the pitch-black water of the Creek and the neighborhood surrounding the Creek was filled with a distinctive odor from the water.

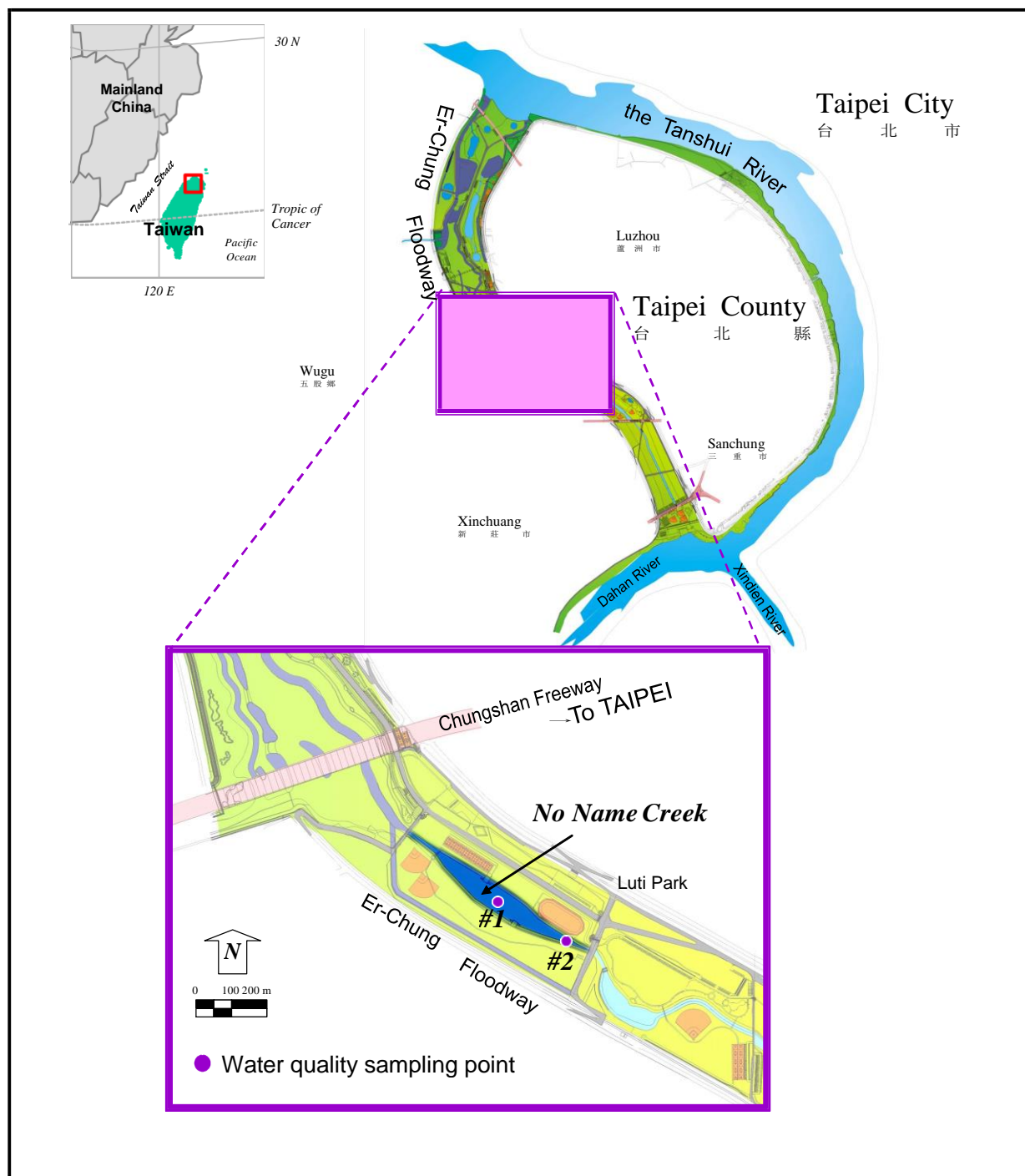
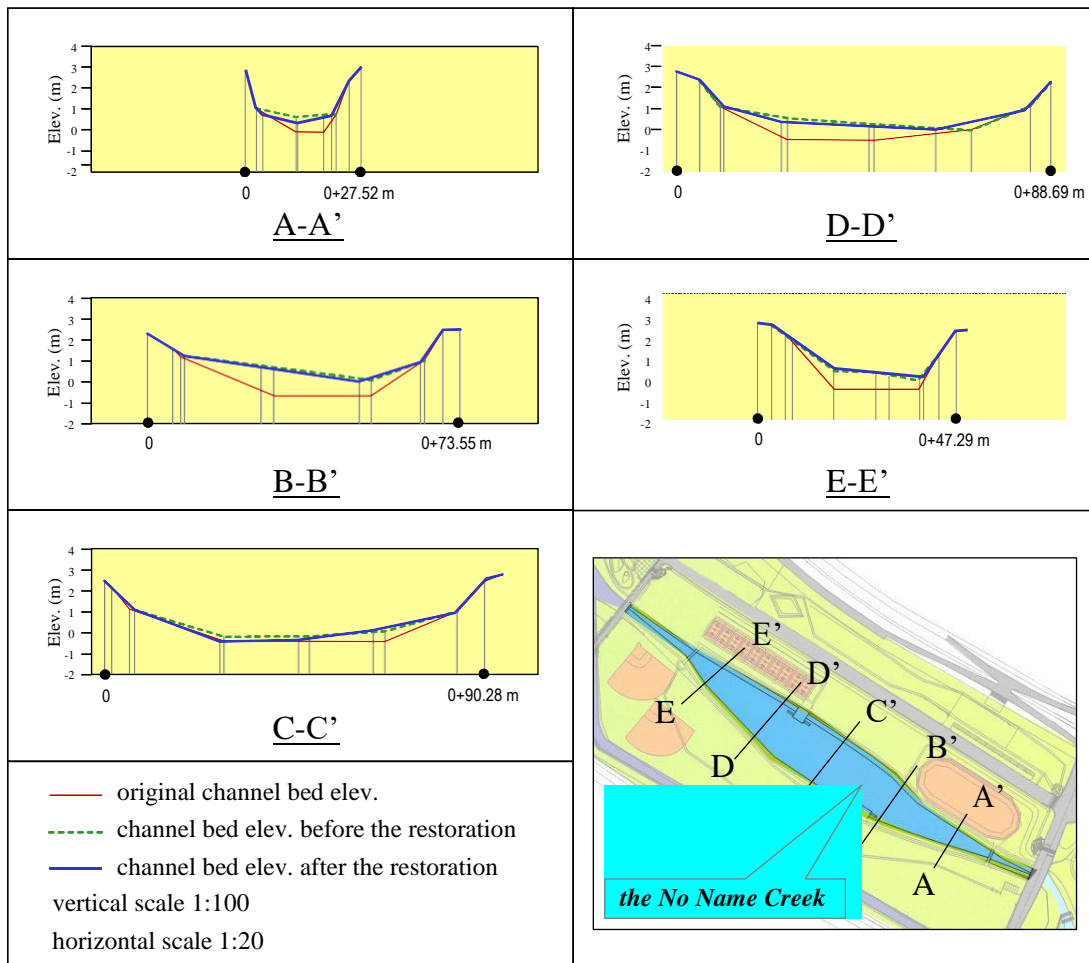


Fig. 1 Map of the restored water Area



**Fig. 2 Channel survey work on No Name Creek**



**Fig. 3 Surveyed channel cross-sections of No Name Creek**

**Table 1 Water quality variation during the restoration**

	Sampling station #1							Sampling station #2					
Date (in 2003)	9/15	9/26	10/6	10/13	10/20	10/31	11/14	9/26	10/6	10/13	10/20	10/31	11/14
DO (mg/L)	ND*	1.0	0.8	0.7	ND*	5.8	3.4	0.8	1.4	ND*	1.4	9.3	7.7
BOD <sub>5</sub> (mg/L)	39.4	15.9	32.4	17.7	35.4	20.5	18.3	17.6	28.7	53.9	60.2	16.7	19.6
TP (mg/L)	1.73	2.67	2.69	1.88	2.24	1.30	2.32	3.09	2.56	2.19	3.07	1.36	2.38
COD (mg/L)	170	103	157	94	159	80.5	79.7	163	125	265	212	95	90.7
Turbidity (NTU)	33	41	83	35	57	20	25	52	29	72	64	28	28
SS (mg/L)	42.1	28.9	83.1	33.1	46.7	32.6	38.7	45.1	47.3	62.5	75.3	52.0	55.4
NH <sub>3</sub> -N (mg/L)	18.1	17.0	16.8	25.2	27.0	15.2	12.7	18.2	12.1	21.6	39.0	18.4	12.5
TN (mg/L)	19.8	18.3	17.8	26.3	27.9	16.4	18.8	22.0	13.8	22.4	46.0	19.4	18.3

\* <0.5 mg/L

No data were taken on 9/15 at station #2

### The Restoration

With no permanent facility needed, the in-situ bio-stimulation technique only requires that given concentration of the liquid products be mixed into the polluted water. In this study, roughly 4,100 liters of the products which represented up to 30 mg/L of product concentration in the Creek were manually sprayed on the water surface at weekly intervals (Fig.4) over a six-week period. Water quality data from samples taken at two stations (shown in Fig.1) over specific intervals during the restoration period are given in Table 1.



**Fig. 4 Manual spraying of Biofeed products to No Name Creek**

It can be seen from Table 1, most pollution indicators in the Creek started to drop and DO in the Creek increased significantly after only one week of treatment. Contrary to our desire to completely isolate the Creek from all possible pollution sources during the restoration, a construction work to re-locate a flood gate commenced almost simultaneously with the restoration. The sudden drop of DO in the week between 10/13 and 10/20 (Table 1) was mostly likely caused by some unknown input from the culvert at the upper end of the Creek and non-point pollutants carried by runoff from the dirt and sludge piles created by the flood gate construction.

Other water quality indicators also jumped up around the same two-week construction period, although they all came down after the excavated dirt and sludge piles were removed and three more weeks of bio-stimulation treatment. By mid November, 2003, the water color of the Creek changed from pitch-black to dark brown and the odor around the Creek was completely gone.

To examine the products' ability to reduce organic sludge in the Creek, bottom sludge and sediment thickness at the same five cross-sections shown in Fig. 3 were surveyed again after the restoration to re-estimate bottom sludge and sediment volume in the Creek. The calculation by linear interpolation of the surveyed data showed that the Creek's bottom sludge and sediment volume decreased about 3,000 m<sup>3</sup> during the period. Further tests in the laboratory with the same product concentration added to bottom sludge samples from the Creek also verified that the products did significantly reduce the organic contents of all samples (EITCO, 2004).

Visual inspections around the Creek after the treatment showed that the restoration effect lasted for about two months.

## Conclusions

The continuing application of two particular in-situ bio-stimulation products by the authors and their colleagues in a heavily polluted urban water once again yielded encouraging results. Although the reduction of certain pollution indicators such as total phosphorus, NH<sub>3</sub>-N, and total nitrogen was not significant, the effect of removing BOD<sub>5</sub>, COD, turbidity, and suspended solids was very clear.

In spite of the fact that it was introduced from highly empirical field applications and much of the microbiological reactions involved remain unknown, the ecologically friendly in-situ restoration technology nonetheless has repeatedly proven itself to be effective in restoring certain polluted waters in Taiwan and China. The technology is an effective pollution abatement alternative for many small enclosed or semi-enclosed water bodies in regions or seasons with moderate climate.

Although extensive research into the technologies and the products are still needed, further application of this economical alternative to improve pollution in suitable waters is strongly recommended.

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