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Effects of Industrial Waste Disposal on the Surface Water Quality of U-tapao River, Thailand

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Abstract. Careless disposal of untreated industrial waste on surface water might affect the physical, chemical and biological characteristics of river ecosystem. U-tapao, one of the main rivers of Songkhla lake basin of Thailand is not exceptional one and seriously polluted by industrial waste disposal which come out from different factories on the both sides of river. Untreated waste water from industries discharge on surface water is the leading cause of high biochemical oxygen demand, nitrate, phosphate and low oxygen contents on river. The objective of this study was to evaluate the impact of industrial waste disposal on surface water quality of U-tapao River. Both the effluents and the water at selected points in the river were analyzed for pH, dissolved oxygen, biochemical oxygen demand, electrical conductivity, suspended solids, nitrate, and phosphate in the dry and wet seasons. The results of study showed that the effluents were acidic in both dry and wet seasons on most of sampling stations. While the levels of biological oxygen demand, electrical conductivity, suspended solids were relatively high in dry season. Water at upstream was neutral and high dissolved oxygen where as water at downstream acidic and low dissolved oxygen. This study indicates that industrialization on the U-tapao river basin has contributed to the large scale pollution and this polluted water is not good for human consumption. It is therefore recommended that the disposal untreated wastes should be stopped to save the river water from further deterioration.

Keywords: Industrial waste, Water pollution, Water quality parameters, U-tapao River

1. Introduction

Industrialization is considered the cornerstone of development strategies due to its significant contribution to the economic growth and human welfare, but it carries inevitable costs and problems in terms of pollution of the air and water resources [1]. Specially, water bodies near to industrial area have been extremely affected from disposal of waste which can alter the physical, chemical and biological nature of the receiving water body. So, industrial waste is the most common source of water pollution in the present day and it increases yearly due to the fact that industries are increasing because most countries are getting industrialized [2]. Industrial waste-water originates from the wet nature of industries which require large quantities of water for processing and disposal of wastes. Most industries are therefore, located near water sources [3].

Industrial waste contamination of natural water bodies has emerged as a major challenge, country like Thailand [4]. Estuaries and inland water bodies, which are the major sources of drinking water in Thailand, are often contaminated by the activities of the adjoining populations and industrial establishments. Wastes entering these water bodies are both in solid and liquid forms. These are mostly derived from industrial, agricultural and domestic activities [5]. As a result, water bodies which are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted. The resultant

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effects of this on public health and the environment are usually great in magnitude. Comparing with other sources, industries are the major sources of polluting the river system of Thailand [4]. Wastewater from industries includes employees' sanitary waste, process wastes from manufacturing, wash waters and relatively uncontaminated water from heating and cooling operations. High levels of pollutants in river water systems causes an increase in biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and Fecal coliform and hence make such water unsuitable for drinking, irrigation and aquatic life [6].

With competing demands on limited water resources, industrial pollution remains one of the major problems facing Thailand cities [7]. As societies throughout the world become more aware of the issues involved in water pollution, there has been considerable public debate about environmental effects of effluents discharged into aquatic environments [8]. Wastes entering these water bodies are both in solid and liquid forms. As a result, water bodies which are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted [9]. So, one of the most critical environmental problems of Thailand is improper management of vast amount of wastes generated by various industrial activities [4]. In the case of U-tapao river basin, most industries have been using large volume of water but without efficient wastewater treatment plants; and so, routinely discharge their wastes directly into river. So, the objective of this study was to evaluate the effects of industrial waste disposal on U-tapao river from the collected data of fourteen monitoring stations.

2. Study Area

U-tapao is a sub-basin of Songkhla lake basin which is located at southern part of Thailand. The basin is about 60 km long from north to south, and 40 km wide from west to east, and total coverage is about 2,170 square kilometres. U-tapao river, the most important river in the basin is 68 km long and approximately 3–8m deep. This river originates from Bantad mountain and flows through Hatyai municipality before emptying into the outer part of Songkhla Lake. Like other rivers, U-tapao is very much affected from point and non point sources of the basin. Major sources of waste discharged into the U-tapao river are from rubber, parawood, and seafood processing industries. Recent rapid urban development in and around Hatyai city puts an even heavier burden on the environment. Untreated industrial and domestic wastewater contributes to water quality deterioration for waterways around Hatyai, which also severely affect Hatyai's drinking water sources.

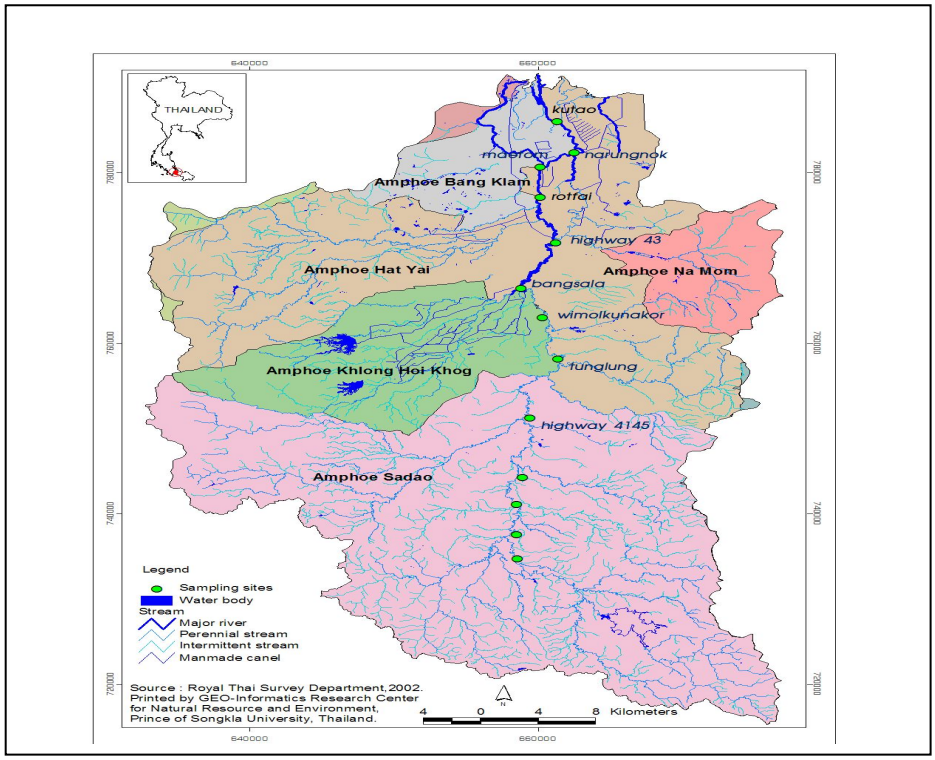

Fig. 1: U-tapao river basin and 14 water quality monitoring stations

3. Materials and Methods

The study was carried out on U-tapao River basin and fourteen monitoring stations were selected for this study. Stations I-VII (Soissangartit, Huatanon, Tonkor, Highway 4145, Tuunglung, and Pracharuamjai) are represented as upstream, stations VIII-XI (Wimoluanakom, Bangsala, Highway 43, and Rotfai) are represented midstream, and stations XII-XIV (Maetom, Narungnok and Kutao) are represented downstream characteristics of river (Figure 1). Water quality data from the year 2001 - 2010 were collected from existing monitoring framework done by the Regional Environment Office 16, Songkhla. The water quality parameters for this study were temperature, pH, conductivity, suspended solid (SS), salinity, biological oxygen demand (BOD), and dissolved oxygen (DO). Industrial related data were obtained from Southern Remote Sensing Centre, Thailand. In this study, data were analyzed by using Statistical Package for Social Science (SPSS) software. Based on data, a number of statistical tests were performed with industrial and water quality data. Correlation analysis was used to examine the strength and significance of the relationships among industrial types and water quality parameters. One-way ANOVA test was performed to test whether mean values of water quality parameters of different monitoring stations vary spatially and temporally or not.

4. Results and Discussions

Overall, the most of industries are located on the banks of river and about 24.9 % industries are located in the upstream, 65% industries are located in midstream and 10.1% are located in downstream region. Administratively, the basin is divided into five districts; Sadoo, Klong Hot Khog, Na Mom, Hatyai, and Bang klam (Figure 1.). In Sadoo district; 8(10.49%) Concrete, 32(41.6%) Rubber, 14(18.2%) Furniture, 9(11.7%) Plastic, 2(2.6%) Metal, 3(3.9%) Service and 3(3.9%) Food industries are located. Similarly, in Klong Hot Khog district; 4(80%) Concrete and 1(20%) Furniture industries are located. In Na Mom district; 1(8.3%) Concrete, 2(16.7%) Rubber, 2(16.7%) Furniture, 2(16.7%) Plastic and 2(16.7%) Food industries are located. In Hatyai district; 16(18.7%) Concrete, 36(19.6%) Rubber, 28(15.2%) Furniture, 13(7.1%) Plastic, 9(4.9%) Metal, 49(26.6%) Service and 24(13%) Food industries are located. In Bang klam district; 5(16.1%) Concrete, 8(25.8%) Rubber, 8(25.8%) Furniture, 4(12.9%) Plastic, 5(16.1%) Service industries are located (Figure 2).

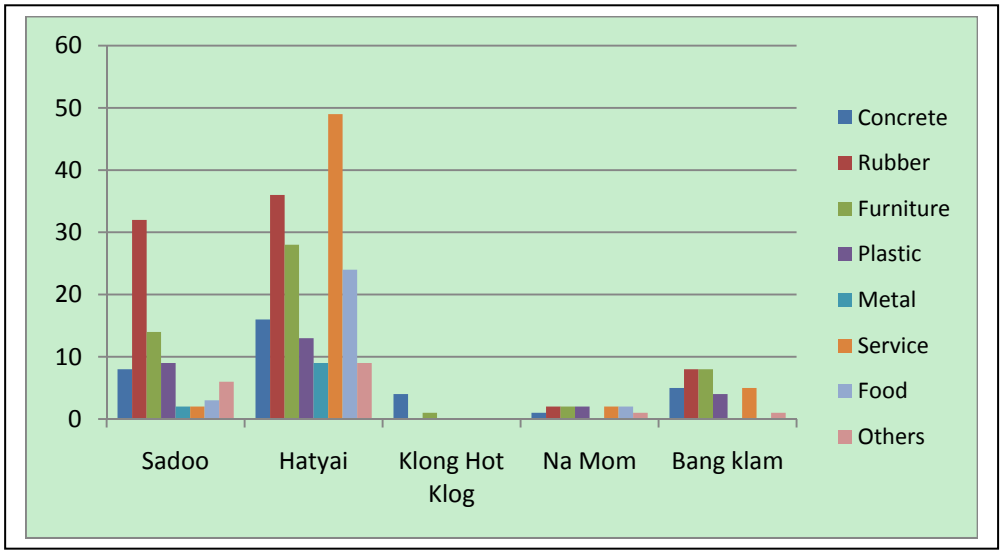

Figure 2: Distribution of industries on five districts of U-tapao river basin

For the case of water quality, Mean and standard deviation (SD) of temperature of U-tapao river was 28.7 ^{0}C and 1.77 ^{0}C and minimum and maximum were 26.2 ^{0}C and 34.2 ^{0}C, respectively. Similarly, mean and SD of pH value of river was 6.37 and 0.88. Mean and SD of SS were 41.75 mg/L and 21.83 mg/L and minimum and maximum values were 11 mg/L and 151 mg/L, respectively and. Mean and SD of BOD were 3.52 mg/L and 3.1 mg/L and mean and SD of DO were 4.07 mg/L and 1.55 mg/L. Water quality parameters;

temperature, BOD, DO, and suspended solid were differed on different monitoring stations with significant difference ($p < .05$) except pH value. Similarly, water quality parameters; temperature, BOD, DO, SS, TCB, and FCB were differed on different regions of stream where as pH, Nitrate and Phosphate were not differed (Table 4).

Table 1: Mean and Standard deviation of water quality parameters (WQP) of upstream, midstream and downstream regions of U-tapao river

WQP	Up-stream	Mid-stream	Downstream	F	p
Temperature	27.71±0.36	29.56±0.42	29.06±0.20	16.51	< 0.05
pH	6.58±0.04	6.34±0.07	6.46±0.05	0.78	0.67
BOD	2.42±0.34	4.22±1.38	2.96±0.12	6.55	< 0.05
DO	3.85±0.71	2.48±0.28	2.6±1.14	11.79	< 0.05
SS	21.56±5.87	65.39±18.34	39.78±9.28	3.45	< 0.05
TCB	13734±345	19675±4567	17456±5621	4.23	< 0.05
FCB	9451±349	12896±3278	12317±3421	3.98	< 0.05
Nitrate	0.19±0.04	0.21±0.07	0.08±0.05	0.32	0.28
Phosphate	0.03±0.005	0.05±0.04	0.04±0.009	0.27	0.32

Table 2: *Results of the Karl Pearson's correlation analysis on water quality variables and Factories size in U-tapao river basin*

WQP	Factories size						
	Concrete	Rubber	Furniture	Plastic	Metal	Service	Food
Temperature	0.29	0.06	.07	-.05	0.41**	0.02	0.16
pH	-.03	-0.23	-.12	-.16	-25**	0.01	0.21
SS	0.31*	0.46*	.58**	-0.12	0.21	0.23	0.54*
BOD	0.02	0.21	0.37**	0.21	0.13	0.21	0.37**
DO	0.03	-0.31*	-0.07	0.01	-0.06	-0.01	-0.21

*p<.05,**p<.001

From the correlation analysis between the numbers of factories with water quality parameters, some water quality parameters have shown significant results. For example, SS had positive relationships with Concrete industry ($r = 0.31$, $p < .05$). SS and DO had positive and negative relationship with Rubber industry ($r=0.46$, $p<0.05$ & $r=-0.31$, $p<0.05$). Temperature and pH had positive and negative relationship with Metal industry ($r=0.41$, $p<0.01$ & $r=-0.25$, $p<0.01$). And, SS and BOD had positive relationship with Food industry ($r=0.54$, $p<0.05$ & $r=0.37$, $p<0.01$).

Over the last ten years, the combination of different factors affected the water quality of U-tapao river and turned it into a polluted unnatural habitat and unhealthy ecosystem. Among the factors that polluted the river, one of the most important causes was the discharge of waste from industries near to river. Results from the statistical analyses indicated that different types of industries were significantly correlated to many water quality variables in the U-tapao river basin (Table 2). From the results, it indicated that the higher amounts of pollutions were found in the regions where the higher numbers of industries were located. Most of industries were located in the midstream region and the pollution level was also high in this region (Table 1).

The SS is directly related to the amount of materials in the water, it was observed that SS was positively related with all types of industries. Decreased level of Dissolved oxygen (DO) was distinctly noticed on mid-

stream region, but in contrast to this BOD was increased in the same region. This indicates the high load of organic pollutants flourishing which flourish the growth of decomposer organism that deplete DO of the surface water and thereby increase BOD load. Increase on phosphate and nitrate were noticed in the surface water on mid and downstream of river due to the cumulative effects of the addition domestic sewage, human interferences, landfills and addition wastes from industrial sectors. The average temperatures of the midstream and downstream were higher than upstream temperature upstream. This may be due to the difference in time of sample collection and reduced vegetation on downstream regions. The pH values of all regions were acidic (pH< 7.00) which indicates the influx of acidic waste entering the river.

5. Conclusions

River pollution due to industrial waste discharge is one of the major environmental problems of U-tapao river basin. From this study, it can be concluded that the surface water pollution in U-tapao river along the industrial areas is extremely high and it is due to uncontrolled and unregulated effluents and waste water from industries. Manny industries of these areas do not have treatment plants and discharge their effluents untreated manner. This study also indicates that industrialization on the U-tapao river basin is very much link with water quality of river. By current water quality standards, the water of river does not useful human consumption can be regarded as polluted river in terms of water quality parameters. It is therefore recommended that the careless disposal of industrial waste without pretreatment should be stopped to save the river water from further deterioration.

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