

## RESULT

### Wetland's characteristics

#### Base-line and Profile study of wetland

##### *resulted description of the studied wetland*

The studied wetland is polygon in shape having the total length of shoreline of about 213 m. It covers the total area of 3,019 m<sup>2</sup> with the depth ranging from less than 0.3 m to 1.6 m (in the studied time interval.), estimated average depth is 0.93 m with estimated water volume of 2,799.44 m<sup>3</sup>. From 3.019 m<sup>2</sup> of total surface area of the wetland, about 1,007 m<sup>2</sup> (33 %) to the west bank was silted and aggressively invaded by a water-tolerated grass species, *Panicum repens* Linn., while the rest of the area was dominantly occupied by water hyacinth with other few species of macrophytes scattering and fringing.

There are 2 main inlets flowing into the studied wetland; one is from the pig manure biogas unit, about 50 meters away on the southwest bank, which normally regularly flow into wetland everyday; another one from cattle farm, about 50 meters on the southeast bank, which has much less wastewater flows irregularly in. There is also another inlet channel, on the southern bank, from the adjacent rain pond whereas the reserved rain-water is sometimes drained into the studied wetland (twice during the study period.) The total flow-in volume of wastewater was estimated to be about 20 m<sup>3</sup> leading to the wetland's retention time estimation which results 140 days.

The studied wetland, locally called ‘ water hyacinth pond,’ has been accepted the draining of wastewater from both animal farms for long period without any proper maintenance except water hyacinth hand-removal 2 times, the last one was about 3 years ago. The precipitation in the area is low, there was no significant rain fall recorded in the area during the study period.

Surrounding activities which regularly occur nearby the studied wetland include cattle grazing along the wetland’s banks and shallow water, draining used water from the office and laboratory of the Biogas Advisory Unit on the west bank. The studied wetland is also a refugee for several species of animals: birds, amphibians, fish, reptiles and insects. During the studied period, it was observed that birds usually stalk around the blanket of water hyacinth, looking for fish, insects and frogs for feeding. Snakes and other reptiles were also regularly found on the banks.

#### *Physical dimension*

Table 7. Physical dimension of the studied wetland.

Surface area (m <sup>2</sup> )	3,019
Estimated water volume (m <sup>3</sup> )	2,799.44
Maximum depth (m)	1.60
Estimated mean depth (m)	0.93
Length of shoreline (m)	213
Estimated wastewater inlet volume (m <sup>3</sup> /d)	20
Retention time (d)	140

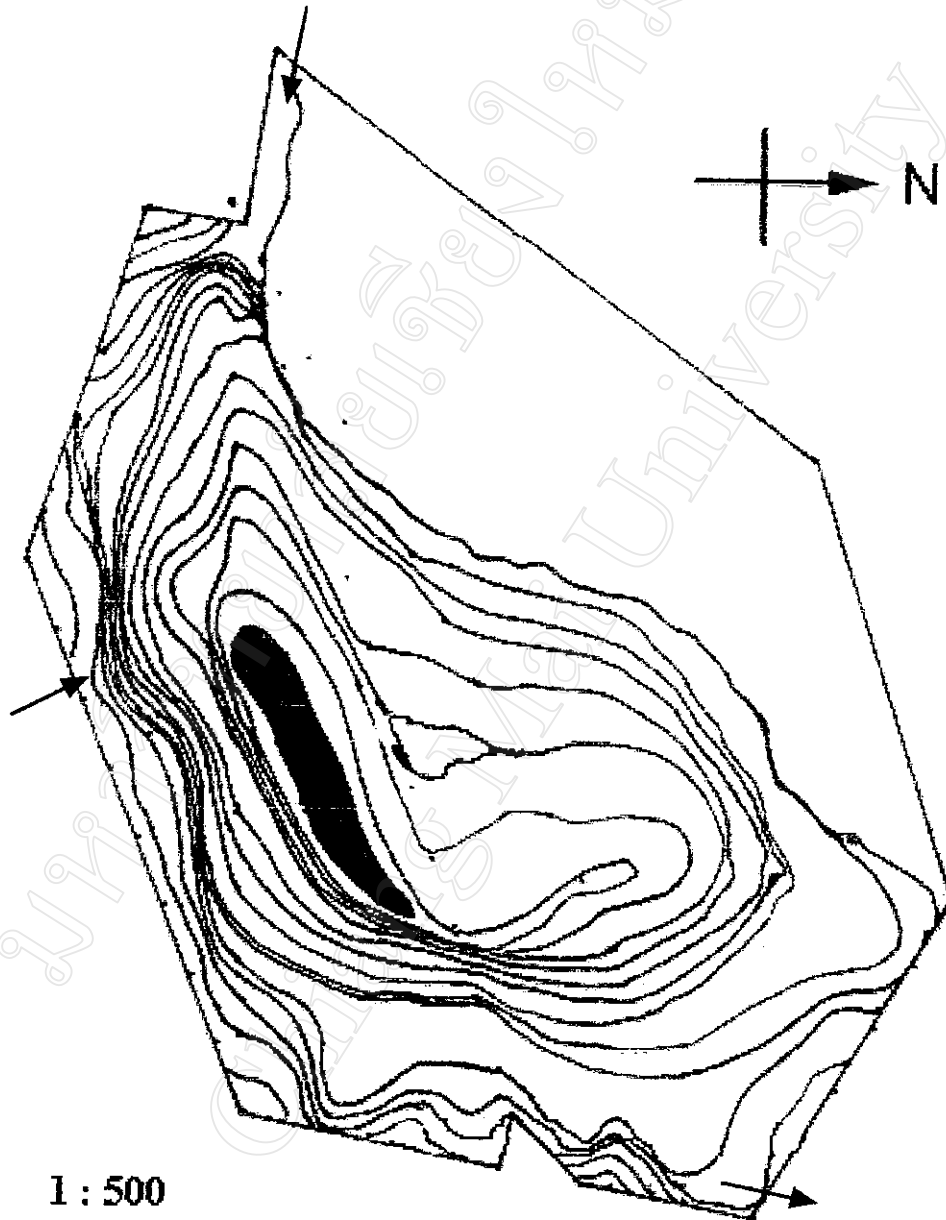
*Contour-line map*

Figure 10. Contour-line map of the studied wetland,  
(arrows indicate inlet and outlet and different depth  
between 2 lines is 0.1 m )

There is a recent phenomenon, happening at the studied wetland, should be recorded since it has effected the usual characteristic of the wetland. At almost to the end of the study, in early April 1998, The Biogas Advisory Unit has constructed an experimental-scale artificial wetland which was located on the southeast bank of the wetland. In doing that, the main channel of effluent from the biogas digester was totally changed and conducted to drain into the new artificial wetland before later on draining into the studied wetland. This has completely changed the physical properties of the wetland.

#### Identification of aquatic plants

There were 4 species of larger aquatic plants, or macrophytes, found in the studied wetland and all of them were identified as a list shown in table 3.

Table 8. List of macrophytes identified from the studied wetland.

Family	Scientific Name	Common Name
Pontederiaceae	<i>Eichhornia crassipes</i> (Mart.) Solms.	water hyacinth
Lemnaceae	<i>Lemna minor</i> L.	duckweed
Araceae	<i>Colocasia esculenta</i>	taro, cocoyam
Gramineae	<i>Panicum repens</i> Linn.	torpedo grass

The macrophytes found in the studied site include two species of floating macrophyte : water hyacinth (*Eichhornia crassipes* (Mart.) Solms) and duckweed (*Lemna minor* L.) Water hyacinth is a dominant species in this wetland occupying most water surface area (up to 60 percent), while duckweeds are found living in between water hyacinth canopies and will spread out quickly as soon as they can get to sunlight. Another species is a water tolerated species of arum family, *Colocasia esculenta* or taro which is found in shallow water nearby the outlet and a little bit more near the west bank. The last species found is a kind of grass from the family of Gramineae, *Panicum repens* Linn., which invaded from the west and southwest bank into the wetland and now already occupied more than 30 percent of water surface of the wetland. Vegetation distribution of these macrophytes is shown in figure 11.

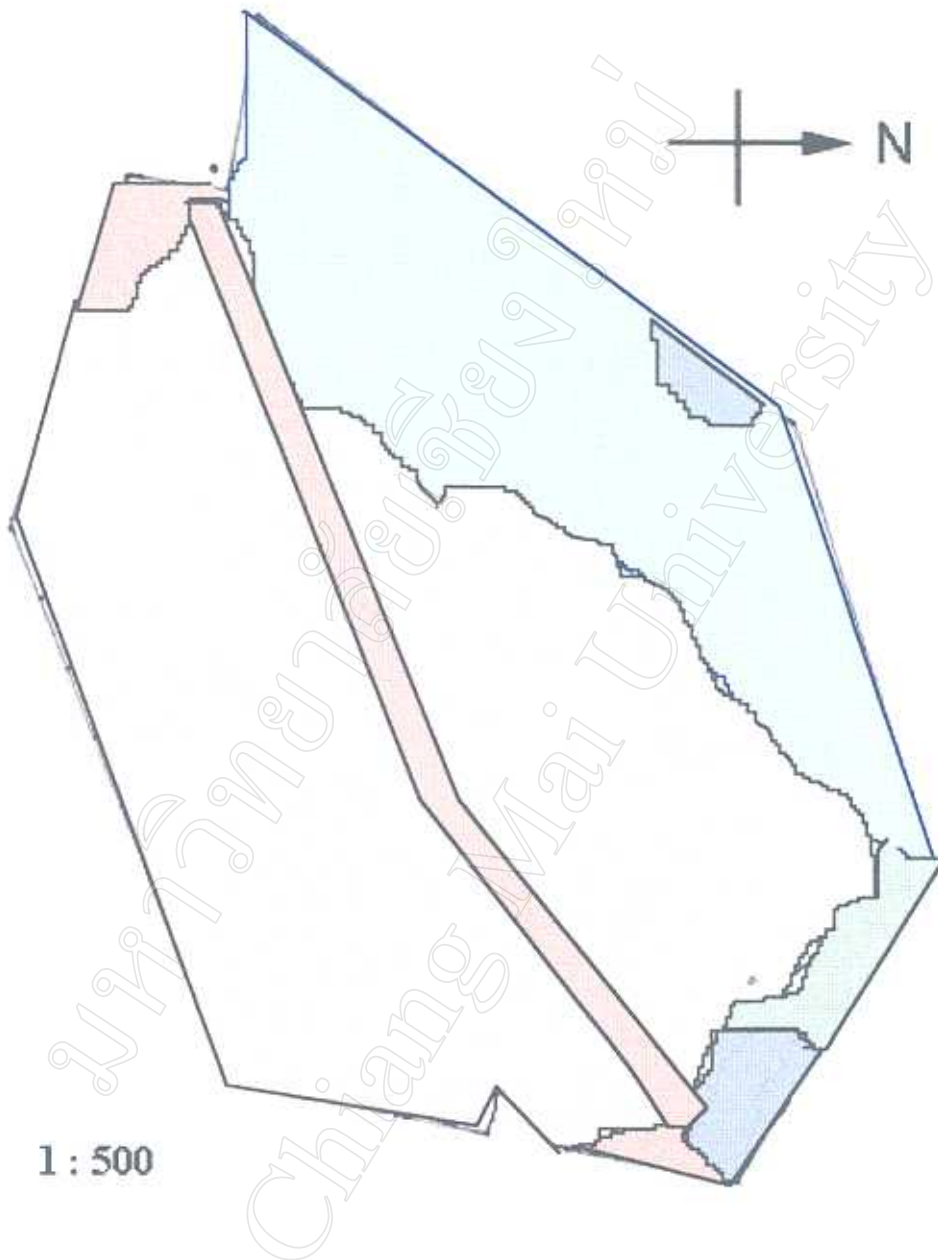






Figure 11. Vegetation distribution map of the studied wetland.

Note :		torpedo grass		taro
		water hyacinth		duckweed

*Water Hyacinth ( Eichhornia crassipes (Mart.) Solms )*

Water hyacinth (figure 12) is generally counted as one of worldwide weeds due to its well spreading and adapting to different aquatic ecosystems in tropics and subtropics regions. Some of the names given in different areas clearly indicate the attitude of people toward this plant, for example, “Blue devil “ and “ Bengal terror “ in India, “ Florida devil “ in South Africa, and “ Japanese trouble “ in Sri Langka. (ผักตบชวา, 2520) In Thailand, It is called “ Java Weed ” because it was first introduced from Malaysia and Indonesia into the country. However, there is a recent new concept of water hyacinth as one of a potential hydrophyte species for wastewater treatment which is now being studied and applied in many countries.

Water hyacinth is a perennial floating macrophyte originally found in Brazil, South Africa. The height ranges from 30 cm up to 90 cm. Its simple Leaf of reniform or cordate shape consists of a large blade and sponge-like petiole while the arrangement of the leaves is like rosettes. The dense subsurface-hanging roots are normally blackish-purple in color caused by anthocyanin. In deep water, this plant will float with the water current, but in shallow water the roots can reach and stick to the sediment like emergent species. Its flower is blue varying with different number of flowers in one spike from 6 to 30. The fruit consists of three lobes stuffed with many round seeds. Although producing seed for reproduction purpose, water hyacinth rarely reproduces by this way. Instead, it adopts the asexual reproduction method by having stolons budding out laterally from the lower part of the stems.

(ผักตบชวา, 2520) and (สุรชัย, 2538)



Figure 12. *Eichhornia crassipes* (Mart.) Solms

(Pontederiaceae, water hyacinth)

*Duckweed ( Lemna minor L. )*

Duckweeds normally occur as mixture of several species. The growth of these plants in fresh waters is most abundant in areas protected from wind-wave action either by taller vegetation or shoreline configuration. Plants present serious problems by forming layer several inches thick on water surface. (เอกสารวิชาการ การฝึ กอบรมนักวิชาการวิห พืชน้ำ, 2520)

There are two similar genera of duckweeds, *Spirodela* with more dense root system and *Lemna* with few roots. Duckweed is also a floating hydrophyte which quite small in size. Leaf or thallus is round or oval in shape with the size of 2 x 3 mm to 4 x 5 mm. Duckweed from *Lemna* Genus has only few roots with the length of 1 to 3 cm and having thin layer of root sheath covering at the root tip. (สุรชัย, 2538)

Very tiny spike flowers are produced at the thallus's base which later turn into fruits where each one consists of only one fertile-seed.

This plants are sometimes used as additional food for ducks and fish, as well as making natural compost for fertilizer.



Figure 13. *Lemna minor* L.  
(Lemnaceae, duck weed)

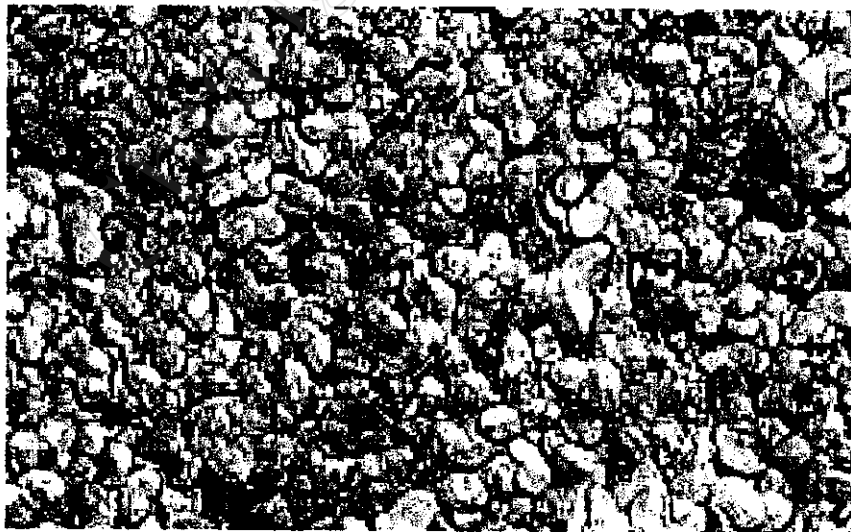


Figure 14. *Lemna minor* L. (magnified)

*Taro, cocoyam ( Colocasia esculenta )*

This edible plant is normally found in moist areas of tropic regions. With high content of starch, some calcium, protein, phosphorus, vitamin A and B1, taro or cocoyam has been feeding several millions of people in the world, especially in developing and undeveloped countries in tropics.

Taro's underground stem is the part which edible. Long sponge-like stems and large cordate-form leaves spring up from this trunk and can reach to almost 1 m high. Both stem and leaf are green. (ประดิษฐ์, 2525)

*Torpedo grass ( Panicum repens Linn. )*

This grass species of Torpedo grass is the annual glabrous herb which often amphibious found worldwide in tropics and subtropics. This grass is normally counted as a weed species invading quickly in the open field even in water areas.

Its color is light green and often with violet older parts. The plant frequently roots at the lower nodes. Linear tapering leaves with thin blades are spirally arranged. The size of a leaf is about 10 - 13 cm long and 0.5 - 0.6 cm wide. Torpedo grass produces flowers and fruits throughout the year. (Radanachaless and Maxwell, 1994)



Figure 15. *Colocasia esculenta* (Araceae)



Figure 16. *Panicum repens* Linn. (Gramineae)

## Wetland's water quality assessment

### Physical parameters

It should be noticed that, both inlets, S1 and S2, are very shallow sites where S2 is normally maintained at the same depth, while S1's depth is fluctuated. However, on the last two sampling days right after the physical change of the studied wetland, watercourse at all sampling sites becomes deeper where S1 becomes a permanent flooded area, while S2 becomes a regular flow-in site with high loading. (table 9.)

Table 9. The record of water depth.

Depth	Date	Site	S1	S2	S3	S4	S5
cm	9-Feb-98		<30	<30	110	120	110
	16-Feb-98		<30	<30	110	120	110
	2-Mar-98		<30	<30	110	120	110
	9-Mar-98		<30	<30	120	130	120
	16-Mar-98		<30	<30	120	130	120
	23-Mar-98		<30	<30	120	130	120
	30-Mar-98		<30	<30	120	130	120
	20-Apr-98		30	30	130	140	130
	27-Apr-98		30	30	130	140	130

Most of the sampling days, the pH value varied in a narrow range where S1 was normally highest. However, on the last two sampling days, after the physical change of the studied wetland, pH values of S1 became not different from other sites. The maximum pH valued recorded was 8.4, while the minimum was 6.8. (table 10.)

Table 10. pH and average values.

pH	Date	Site	S1	S2	S3	S4	S5
	9-Feb-98		8.4	7.2	7	6.9	6.9
	16-Feb-98		8	7	7	7	6.9
	2-Mar-98		7.1	6.8	6.9	6.8	6.8
	9-Mar-98		7.3	6.9	6.9	6.9	6.9
	16-Mar-98		7.4	7	7.1	7	6.9
	23-Mar-98		7.5	7.1	7.4	7.2	7.1
	30-Mar-98		7.8	7.1	7.2	7.1	7
	20-Apr-98		7.5	7.8	7.6	7.4	7.4
	27-Apr-98		7.6	7.8	7.6	7.5	7.5
	Average		7.62	7.19	7.19	7.09	7.04
	SD		0.39	0.37	0.28	0.24	0.25

The same thing happens to water temperature in the wetland. Water temperature in the studied wetland also varied in a narrow range with the maximum of 27.5 °C and the minimum of 18 °C. S1 normally had the highest temperature until after the wetland's physical change where it became not different from other sites. (table 11.)

Table 11. Temperature and average values.

Temp.	Date	Site	S1	S2	S3	S4	S5
C	9-Feb-98		21	18	18.2	18	18
	16-Feb-98		19.5	18.5	18	18	18
	2-Mar-98		29	25	23	23	23
	9-Mar-98		26.5	21	21.5	21	21
	16-Mar-98		26.5	22.5	22.5	22.5	22.5
	23-Mar-98		27.5	22	22	21.5	22
	30-Mar-98		28	22	22.5	22	22
	20-Apr-98		26.5	27.1	25	24.8	25.5
	27-Apr-98		25.5	25.5	25	24.5	24
	Average		25.56	22.40	21.97	21.70	21.78
	SD		3.20	3.07	2.50	2.44	2.50

The flow status (table 12) confirms the effect of physical change of the studied wetland where S1 becomes less flowing and almost static water, while S2 is rapidly turned into a massive-flowing inlet site.

Table 12. The record of flow status.

Water	Date	Site	S1	S2	S3	S4	S5
flow	9-Feb-98		++	+	-	-	-
	16-Feb-98		++	-	-	-	-
	2-Mar-98		++	+	-	-	-
	9-Mar-98		++	-	-	-	-
	16-Mar-98		++	-	-	-	-
	23-Mar-98		+++	+	-	-	-
	30-Mar-98		+	-	-	-	-
	20-Apr-98		-	+++	-	-	-
	27-Apr-98		+	+++	-	-	-

**Legend**

+ = little flow      +++ = massive flow  
 ++ = regular flow      - = static

### Chemical parameters

Chemical parameters were determined in order to assess water quality in the studied wetland. BOD<sub>5</sub> ranged between the maximum of 295.00 mg/l and the minimum of 10.00 mg/l (table 13), where those of COD are 1,053.85 mg/l and 81.29 mg/l, respectively (table 14) For nutrient-parameters; ammonia nitrogen (NH<sub>3</sub>-N) varied in a range of 1,735.20 mg/l and 337.71 mg/l (table 15); nitrate nitrogen (NO<sub>3</sub>-N) varied between 117.46 mg/l and 9.50 mg/l (table 16); and orthophosphate phosphorus (PO<sub>4</sub>-P) varied within the range of 394.54 mg/l and 8.53 mg/l. (table 17)

Table 13. BOD<sub>5</sub> and average values.

BOD <sub>5</sub>	Date	Site	S1	S2	S3	S4	S5
(ppm)	9-Feb-98		200.00	30.00	20.00	10.00	10.00
	16-Feb-98		230.00	48.33	60.00	73.33	26.67
	2-Mar-98		266.67	21.67	11.67	20.00	10.00
	9-Mar-98		240.00	25.00	25.00	21.67	21.67
	16-Mar-98		295.00	170.00	15.00	10.00	17.50
	23-Mar-98		210.00	30.00	20.00	23.33	30.00
	30-Mar-98		206.67	30.00	26.67	30.00	10.00
	20-Apr-98		53.33	50.00	30.00	20.00	30.00
	27-Apr-98		70.00	40.00	30.00	23.33	26.67
	Average		196.85	49.44	26.48	25.74	20.28
	SD		82.49	46.27	14.08	18.95	8.64

Table 14. COD and average values.

<b>COD</b>	<b>Date</b>	<b>Site</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>	<b>S5</b>
<b>(ppm)</b>	17-Mar-98		<b>1053.85</b>	805.77	126.92	125.00	142.31
	24-Mar-98		753.44	240.00	175.08	184.92	243.93
	31-Mar-98		741.29	284.52	228.39	269.03	<b>81.29</b>
	21-Apr-98		232.32	212.96	290.40	271.04	212.96
	28-Apr-98		212.90	212.90	232.26	261.29	251.61
	Average		598.76	351.23	210.61	222.26	186.42
	SD		365.55	255.77	62.08	65.08	72.90

Table 15. NH<sub>3</sub>-N and average values.

<b>NH<sub>3</sub>-N</b>	<b>Date</b>	<b>Site</b>	<b>S1</b>	<b>S2</b>	<b>S3</b>	<b>S4</b>	<b>S5</b>
<b>(ppm)</b>	9-Feb-98		257.73	143.18	164.40	153.79	162.28
	16-Feb-98		416.83	<b>130.46</b>	145.31	213.19	225.91
	2-Mar-98		408.34	160.15	162.28	198.34	219.55
	9-Mar-98		575.92	134.70	308.64	206.82	181.37
	16-Mar-98		575.92	155.91	257.73	264.10	257.73
	23-Mar-98		<b>671.38</b>	96.52	363.79	359.55	378.64
	30-Mar-98		607.74	107.12	346.82	342.58	357.43
	20-Apr-98		276.82	276.82	283.19	187.73	168.64
	27-Apr-98		272.58	276.82	281.07	228.03	215.31
	Average		451.47	164.63	257.02	239.35	240.76
	SD		160.80	66.84	81.72	70.05	78.36

Table 16. NO<sub>3</sub>-N and average values.

NO <sub>3</sub> -N (ppm)	Date	Site	S1	S2	S3	S4	S5
	9-Feb-98		17.11	39.91	33.07	27.37	26.23
	16-Feb-98		42.95	30.03	31.55	23.19	26.23
	2-Mar-98		68.04	23.95	33.83	29.27	30.79
	9-Mar-98		73.36	21.67	36.11	33.07	33.83
	16-Mar-98		117.46	79.44	10.26	12.54	9.50
	23-Mar-98		58.16	30.79	50.56	42.19	49.04
	30-Mar-98		55.88	36.87	49.04	39.91	46.75
	20-Apr-98		42.19	35.35	42.19	39.91	46.75
	27-Apr-98		43.71	42.19	42.19	41.43	44.47
	Average		57.65	37.80	36.53	32.10	34.84
	SD		27.90	17.05	12.00	10.03	13.16

Table 17. PO<sub>4</sub>-P and average values.

PO <sub>4</sub> -P (ppm)	Date	Site	S1	S2	S3	S4	S5
	9-Feb-98		249.52	279.38	282.58	304.97	263.38
	16-Feb-98		245.25	307.10	295.37	308.17	318.83
	2-Mar-98		127.96	127.96	351.89	293.24	325.23
	9-Mar-98		223.93	125.83	298.57	266.58	277.24
	16-Mar-98		42.65	8.53	10.66	74.64	53.32
	23-Mar-98		341.22	28.79	415.87	415.87	394.54
	30-Mar-98		351.89	31.99	394.54	383.88	383.88
	20-Apr-98		191.94	255.92	207.93	198.34	159.95
	27-Apr-98		223.93	223.93	213.27	223.93	191.94
	Average		222.03	154.38	274.52	274.40	263.15
	SD		96.37	115.99	122.09	101.69	111.10

The statistical analysis for chemical parameters was carried out concerning two points of determining-concept; (i) to determine differences of chemical values among sampling sites before the physical change of the wetland; and (ii) to determine the differences of those values among sampling sites after such change.

The result has indicated that, before the physical change of the wetland, chemical values at S1 were statistically (99.95 %) different from those of other sampling for all parameters except orthophosphate -phosphorus where the values of all sampling sites were not different. However, there were no significant difference between chemical values of the mid-wetland sites S3, S4 and the outlet S5. This indicates that there were some levels of treatment capacity at only the beginning part of the wetland while there was no treatment after the wastewater entering into mid-wetland areas. The chemical values of additional inlet S2 were also significantly (99.95 %) different from those of other sampling sites which confirms the original believe that inlet S2 is different from S1.

After the physical change of the studied wetland caused by the construction of the artificial wetland on the southern bank, the situation of chemical values among sampling sites became different. Inlet S1 and S2 became not different from other sampling sites for all parameters except BOD<sub>5</sub>. Therefore, it was also confirmed the sensitivity of the studied wetland to surrounding condition by changing its physical properties and having the effect on other properties especially its capacity of wastewater treatment.