Effects of heavy metals on plankton, water quality and fish in Pak-pra canal, Phatthalung province, Thailand

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Abstract

The objective of this study is to investigate the heavy metals in the water in Upstream and canal mouth at the Pak-pra canal and find the relationship between heavy metal, water quality, plankton and the number and types of fish. Collected data by divided study area into 2 areas (Upstream and canal mouth) Fixed 6 points at each area. Study duration was May to September 2018. Collected data once a month.

Our result show that, we found 8 heavy metals, namely Fe, Zn, Ba, Mn, Pb, As, and Cd, Cr. The concentration of metal Fe, Pb, Mn and Ba exceeded the standard volume from Pollution Control Department of Thailand but Cd, Cr, Zn and As not exceeded the standard value. Some water quality parameters are negatively associated with Ba, Zn, Pb, Cr and As and has a positive relationship with Ba and Cr. The number of certain Phytoplankton is positively correlated with Ba, Mn, Zn, Cr and is negatively associated with Cd. *Frontonia* protozoa is positively correlated with Zn, Ba and Mn. *Barbonymus gonionotus* and *Rasbora sumatrana* have a positive relationship with Pb. *Strongylura stronggylura* are negatively associated with Mn. *Clupaichthgs aesarnensis* has a negative relationship with Zn. The total number of fish found in the Pak-pra canal had a positively correlated with Fe. This study is an important information in raising awareness both management of environmental problems and public health care of the people.

Keywords: heavy metals, water quality, plankton, canals, Pak-pra

Introduction

The research entering the area to explore the area for research and talking with villagers living near the Pak Pra canal during April 2018, it was found that fish died after rain. When we are talking to the villagers, knowing that fish often die after rain which is likely to be caused by rain that has washed away the chemicals on the soil down to the canal. Pak Pra Canal is an important canal in Phatthalung Province. That flows from various rivers converging into Pak Pra canal then flows out into Songkhla Lake. Pak Pra Canal is like a gateway to connect the important rivers of agricultural use and allow fish to swim in and out. Causing the mouth of the Pak Pra Canal to become a gathering place for fish and become an important source of fish, with villagers setting up a large number of fish. Villagers around the area find life by catching fish in the canal. Which has a fish that is famous for the province that can only be caught from this area e.g. *Clupeichthys aesarnensis*, *Corica sorbowa*, and *Leiognathu decorus*. From this reason, we are interested in to studying the concentration of heavy metals in the Pak Pra Canal.

Research questions

1. Is there any heavy metal at the mouth and upstream of the Pak Pra canal?

   Are they different?

2. If there are heavy metals in the canal, how about their amounts? Do the amounts exceed the standard from Pollution Control Department?
3. Is there any effect of heavy metals on the water quality, plankton and fish in the Pak Pra canal?

Hypothesis

1. There would be some heavy metals in the Pak Pra canal, and amounts of some heavy metals would exceed the standards from Pollution Control Department
2. The amount of some heavy metals would be higher in the upstream compared to the mouth of the canal because of higher activity of villagers at the upstream
3. Some heavy metals should have effects on water quality, plankton, and fish in Pak pra canal

Materials and methods of research

1. Study area

This research was conducted in the area of Pak-pra canal, Phanang Tung Subdistrict, Khuan Khanun District, Phatthalung Province.

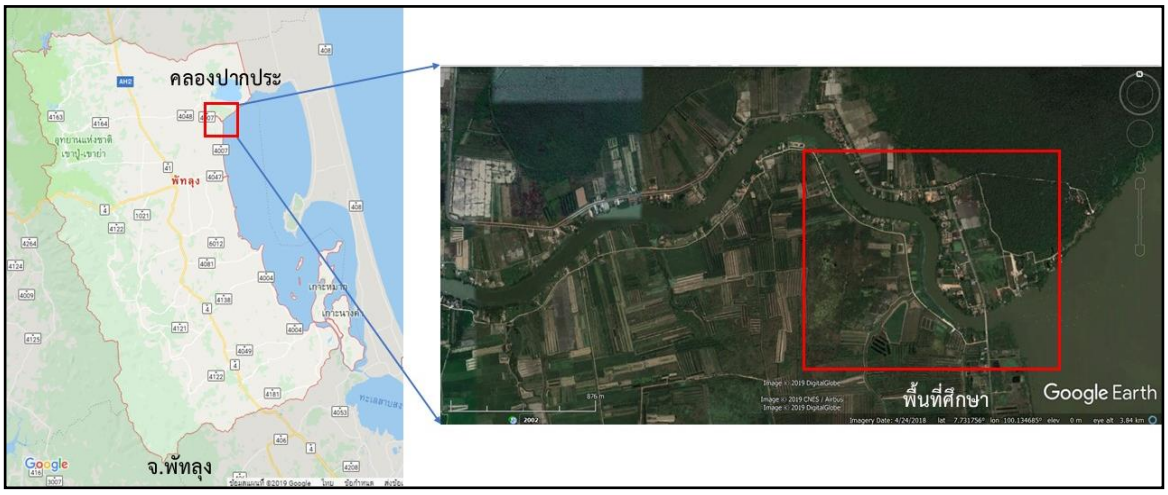


Figure 1 Study area at Pak-pra Canal, Khuan Khanun District, Phatthalung Province

2. Time duration and sampling point setting

Sampling The researchers collected fish samples. Plankton and water quality in the area where the villagers catch fish by using giant yokes during the months of May to September 2018, the 4th week of the month. Mouth Each area carries out a study of 6 points, with each spacing depending on the location of the giant that the villagers have installed. Distance between upstream (A1-A6) and a mouth of Pak-pra Canal (B1-B6) approximately 1.40 kilometers as shown in Figure 2

Figure 2 Determining fish collection points, water quality and plankton Pak Pra Canal Area

3. Collecting water samples to measure heavy metals

The collection of water samples in each the study area 6 points with a total of 12 points. The study collected water samples at 12 sample point during April to September 2018, collected once a month. Bring the water to analyze the type and amount of heavy metals at the Scientific Instrument Center of Walailak University.

4. Water quality data collection

Sampling of water quality data in the area where villagers catch fish by flattering in the study area at the mouth of the canal, 6 points and 6 upstream with a total, 12 study points from April to September 2018, collected once a month and collecting water data from 06.00-12.00 hrs. Villagers will be flattering in the morning. With equipment used in water quality analysis as shown in Table 1 and input data in GLOBE Observer.

Table 1 Equipment used in water quality analysis

Parameter	Equipment
Surface temperature (๐C)	Infrared Thermometer
Air temperature (๐C)	Infrared Thermometer
PH - pH	PC Test 35 Multi-Parameter
Dissolved oxygen values (DO) (Mg / L)	Lutron PDO-519
Conductivity (EC) (s / cm)	PC Test 35 Multi-Parameter
Suspended quantity (TDS) (ppm)	TDS meter TDS-EZ
Nitrate (NO3) (Mg / L)	Laquatwin Nitrate meter

5. Plankton sample collection

Sampling the water for analyze plankton at a depth of 30 centimeters by using a plankton net traction bag with a horizontal drag at the surface level. Drag the bag horizontally for a period of 60 seconds. Collect 120 ml of sample water. Put on a plastic bottle. 6 samples were collected at upstream and canal mouth each time. Analyze types of the plankton and count the numbers of plankton samples by sampling into the slides and using the microscope.

6. Fish sampling

Samples of fish data from time period 6.00-12.00 am. The villagers can be caught from the giant chines net size that has 11x11 m^2). In put the giant chines net about 15 minutes, so it will be flattering. Did it 3 times. Using swing took the fish from the giant chines net. Count the number and type of fish.

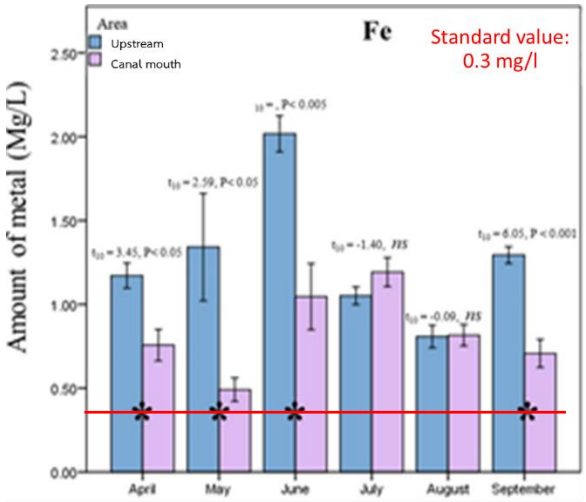
7. Data analysis

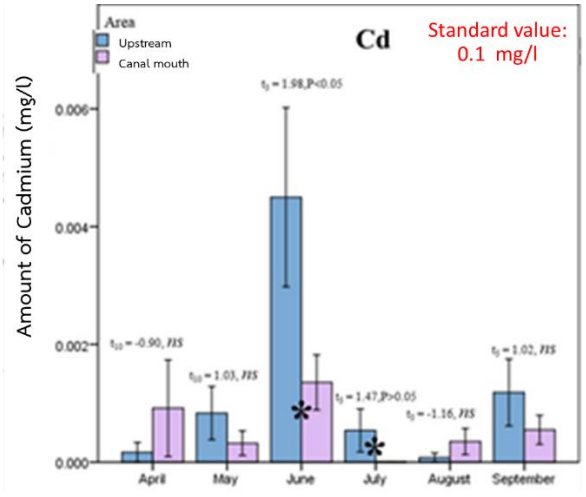
Statistical data were analyzed by using the SPSS program, version 22, as follows: 1) using mean and standard error of mean to explain the amount of metal in the canal and the mouth of the canal 2) using Independent samples *t*-test analyses differences in the amounts of heavy metals between upstream and canal mouth. 3) Using spearman correlations analyses the relationship between heavy metal, water quality, number of fish and the number of plankton types.

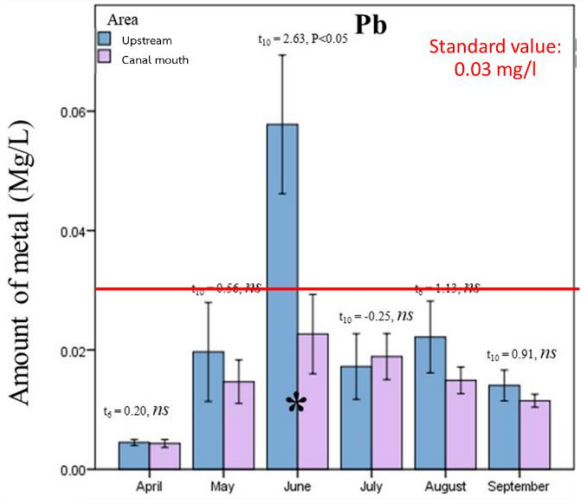
Results

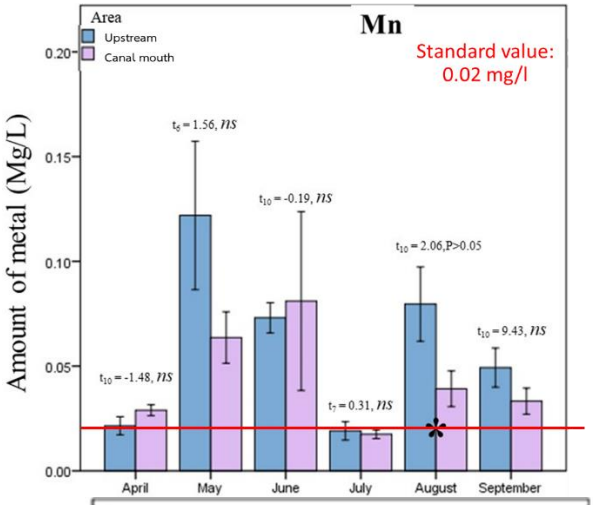
Amounts of heavy mental in upstream and canal mouth in Pak-pra canal

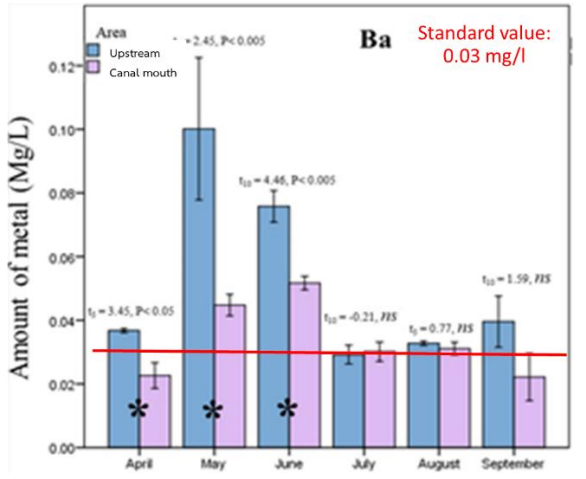
Our result show that amounts of Fe in April, May, June and September in upstream higher than at canal mouth and exceeded the standard value of Pollution Control Department of Thailand. The amount of Cd in June and July in upstream higher than at canal mouth and not exceeded the standard value. The concentration of Pb in June in upstream higher than at canal mouth and exceeded the standard value. The concentration of Mn in every month in upstream higher than at canal mouth and exceeded the standard value. The concentration of Ba in April to June in upstream higher than at canal mouth and exceeded the standard value. The concentration of Cr in September in upstream higher than at canal mouth and exceeded the standard value. The concentration of Zn in August in upstream higher than at canal mouth and not exceeded the standard value. The concentration of As in June in upstream higher than at canal mouth and not exceeded the standard value (Figure 3).

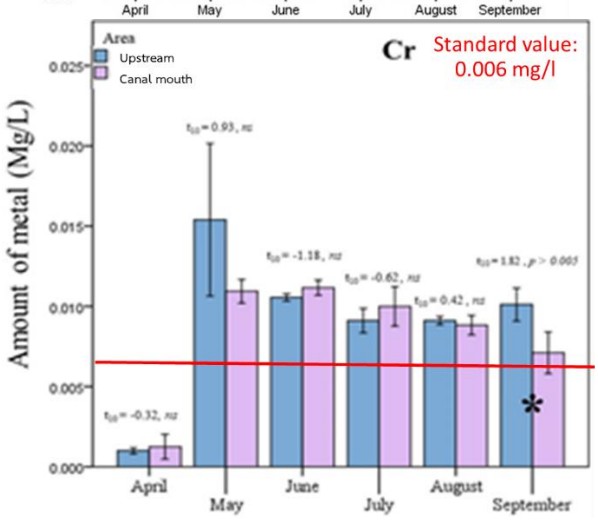

Area
Upstream
Canal mouth
Fe
Standard value:
0.3 mg/l
Amount of metal (Mg/L)
April
May
June
July
August
September


Area
Upstream
Canal mouth
Cd
Standard value:
0.1 mg/l
Amount of Cadmium (mg/l)
April
May
June
July
August
September


Area
Upstream
Canal mouth
Pb
Standard value:
0.03 mg/l
Amount of metal (Mg/L)
April
May
June
July
August
September


Area
Upstream
Canal mouth
Mn
Standard value:
0.02 mg/l
Amount of metal (Mg/L)
April
May
June
July
August
September


Area
Upstream
Canal mouth
Ba
Standard value:
0.03 mg/l
Amount of metal (Mg/L)
April
May
June
July
August
September


Area
Upstream
Canal mouth
Cr
Standard value:
0.006 mg/l
Amount of metal (Mg/L)
April
May
June
July
August
September

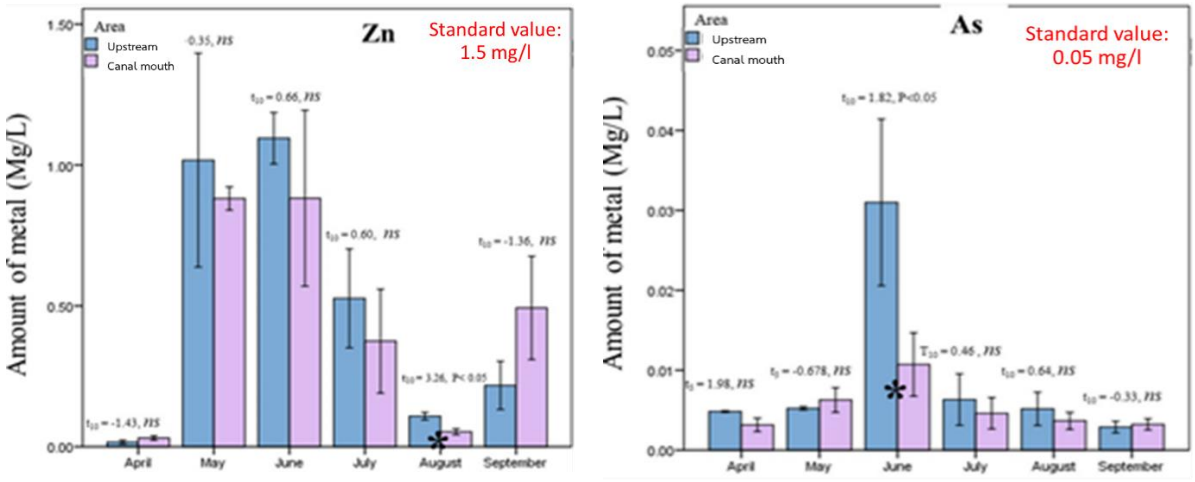


Figure 3 Heavy metal (a) Fe, (b) Cd, (c) Pb, (d) Mn, (e) Ba, (f) Cr, (g) Zn, and (h) As in upstream and canal mouth the river on April to September 2018 in Pak-pra Canal Area.

Correlations between heavy metals and water quality at Pak Pra canal

We found that Zn, Ba, Mn, As, Pb, and Cr were negatively correlate with electrical conductivity, TDS and Nitrate. Ba and Cr were positively correlate with pH, Mn was positively correlate with temperature (Table 1).

Correlations between heavy metals and planktons at Pak-pra canal

Our study found that Cd was negatively correlate with *Nitzschia* numbers. Zn, Ba, Mn and Cr were positively correlate with *Volvox*, *Evicular*, *Pediastrum*, and *Frontonia* number (Table 2).

Correlations between heavy metals and fish at Pak Pra canal

We found that Zn and Mn were negatively correlate with Thai river sprat number and Spottail needle fish. Lend was positively correlate with Sumatra rasbora. Iron was positively correlate with total number of fish (Table 3).

Table 1 Correlations between heavy metals and water quality (N = 12), (* *P* <0.05, ** *P* <0.005, *** *P* <0.001)

Parameter	**Mean±SD**.	**Types of Heavy metal**							
			Fe	Zn	Ba	Mn	Pb	As	Cd	Cr
pH	7.39±0.06	R	0.105	0.233	**0.517***	0.345	0.034	0.117	0.057	**0.483***
		P	0.658	0.324	**0.020**	0.136	0.887	0.623	0.811	**0.031**
Dissolved Oxygen (Mg/L)	7.16±1.51	R	0.032	0.086	-0.086	-0.389	-0.120	-0.370	-0.364	-0.035
		P	0.892	0.717	0.719	0.090	0.613	0.108	0.114	0.885
Electrical conductivity (µs/cm)	197.77±17.26	R	-0.235	-0.340	**-0.469***	**-0.663****	**-0.583****	**-0.608****	-0.153	-0.308
		P	0.319	0.143	**0.037**	**0.001**	**0.007**	**0.004**	0.519	0.187
Total dissolved solids (ppm)	116.91±16.79	R	-0.224	**-0.668****	**-0.701****	**-0.504***	-0.385	**-0.595****	-0.366	**-0.531***
		P	0.342	**0.001**	**0.001**	**0.024**	0.094	**0.006**	0.113	**0.046**
Nitrate (Mg/L)	4.46±1.23	R	-0.346	**-0.714****	**-0.668****	**-0.496***	**-0.583****	**-0.755*****	-0.393	**-0.621****
		P	0.135	**0.000**	**0.001**	**0.026**	**0.007**	**0.000**	0.086	**0.004**
Air temperature (°C)	27.73±0.27	R	-0.206	-0.002	0.225	**0.470***	-0.035	0.273	0.368	0.109
		P	0.383	0.992	0.340	**0.036**	0.882	0.244	0.110	0.648
Water temperature (°C)	29.44±0.40	R	-0.311	-0.300	-0.064	0.096	-0.253	-0.403	-0.334	-0.013
		P	0.183	0.199	0.789	0.689	0.281	0.078	0.150	0.957

**R*= Correlation Coefficient, *P*= Probability value

Table 2 Correlations between heavy metals and plankton numbers (N = 12), (* *P* <0.05)

Plankton	**Types of plankton**		**Types of Heavy metal**							
			Fe	Zn	Ba	Mn	Pb	As	Cd	Cr
Phytoplankton	*Volvox*	R	0.000	0.396	**0.454***	**0.458***	-0.127	0.128	0.145	0.099
		P	1.000	0.084	**0.044**	**0.042**	0.593	0.591	0.543	0.677
	Navicula	R	-0.109	-0.085	0.158	**0.546***	0.012	0.292	0.000	-0.134
		P	0.647	0.722	0.506	**0.013**	0.959	0.212	1.000	0.574
	Nitzschia	R	-0.147	-0.364	-0.257	0.016	0.068	-0.147	**-0.465***	-0.280
		P	0.537	0.115	0.274	0.948	0.775	0.537	**0.039**	0.231
	Pediastrum	R	-0.213	**0.457***	0.394	0.343	0.070	0.116	0.071	**0.502***
		P	0.368	**0.043**	0.085	0.138	0.769	0.626	0.767	**0.024**
Protozoa	*Frontonia*	R	-0.139	**0.488***	**0.516***	**0.459***	-0.052	0.116	0.060	0.317
		P	0.560	**0.029**	**0.020**	**0.042**	0.829	0.626	0.801	0.173

**R*= Correlation Coefficient, *P*= Probability value

Table 3 Correlations between heavy metals and fish numbers at Pak Pra canal (N = 12), (* *P* <0.05, ** *P* <0.005)

Types of Fish		**Types of Heavy metal**							
		Fe	Zn	Ba	Mn	Pb	As	Cd	Cr
Java barb	R	0.401	0.376	0.231	0.158	**0.546***	0.401	0.428	0.231
	P	0.080	0.102	0.328	0.506	**0.043**	0.080	0.060	0.328
Chinese mud card	R	0.403	0.097	0.336	0.215	-0.022	-0.065	0.381	0.367
	P	0.078	0.685	0.147	0.363	0.928	0.785	0.097	0.112
Sumatra rasbora	R	0.406	0.205	0.139	0.133	**0.631****	0.250	0.100	0.264
	P	0.075	0.386	0.559	0.575	**0.003**	0.289	0.675	0. 261
Spottail needlefish	R	0.275	0.033	-0.289	**-0.441**	0.220	0.279	-0.067	-0.067
	P	0.240	0.889	0.216	**0.044**	0.350	0.234	0.778	0.780
Thai river sprat	R	0.249	**-0.445***	-0.198	-0.138	0.019	-0.192	-0.207	-0.005
	P	0.289	**0.049**	0.402	0.562	0.935	0.416	0.381	0.984
Total number of fish	R	**0.492***	0.050	-0.102	-0.265	0.205	-0.021	-0.043	0.105
	P	**0.028**	0.833	0.670	0.259	0.386	0.932	0.857	0.660

**R*= Correlation Coefficient, *P*= Probability value

Discussion

The concentration of heavy metal in the sample collected from upstream and canal mouth in Pak-pra canal at Phatthalung province, Thailand. Our result found that Fe, Pb, Mn, and Ba found higher than canal mouth and exceeded the standard value from Pollution Control Department of Thailand because had more agricultural (rice paddy, palm garden) activity along the canal, and thus, the use of fertiliser at this agricultural site most likely contributed to the increased level of heavy mental in the upstream were caught at this location**.** Tomponkrang and Chaiyakam (1996) found that the concentration of heavy metals in the water at Songkhla Lake (Pak Pra Canal is caused by the integration of various rivers and flow to Songkhla Lake) was higher than the standard criteria: Cd, copper, Fe and Pb.

We found that Zn and Mn were negatively correlate with Thai river sprat number and Spottail needle fish. Pb was positively correlate with Sumatra rasbora. Fe was positively correlate with the total number of fishes. Widianarko *et al*. (200) investigated the relationship between metal (Pb, Zn, Cu) concentrations and fish (Poecilia reticulata) size, and found that there was a significant decline in lead concentrations with the increase in size.

From the study of the relationship between heavy metals and water quality in the Pak-pra canal during April to September, it was found that the pH water was positively correlated with Ba and Cr. The electrical conductivity was negatively correlated with Ba. Mn, Pb and As. Concentration of suspended solids is negatively associated with Zn, Ba, Mn, As and Cr and has a positive relationship with Mg. Nitrate is negatively associated with Zn, Ba, Mn, Pb, As and Cr. *Volvox* has a positive relationship with Br and Mn. *Navicula* has a positive relationship with Mg. *Nitzschia* has a correlation with Cd. *Frontonia* had positively correlated with Zn, Ba, and Mn. Java barb fish was positively correlated with Pb. Sumatra rasbora had a positive relationship with Ca. Spottail needlefish had a negative relationship with Mn. Thai river sprat had a negative relationship with Zn. And the total number of fish found had a positive relationship with Fe. Which, if the concentration of heavy metals contained in the water, resulting in accumulation in fish and plankton will inevitably affect the health of consumers. From the research of Tawatchai thani et al. (2017) studied the concentration of heavy metals in the water sediment and fish found that the concentration of heavy metal accumulation in all 4 types, namely zinc, copper, cadmium, lead in fish, carnivorous and herbivorous fish. Although the concentrations of heavy metals in the fish and water column were detected in higher concentration than standard, the potential for metal toxicity danger may become more severe in the future depending upon the extent of agricultural and domestic wastewater influx into the Pak-pra canal due to human activities in the adjacent areas.

This study is an important information in raising awareness both in the management of environmental problems and public health care. Therefore, information should be published to the public for consideration of the decision to buy food for consumption, including is also a way to encourage farmers to realize and reduce the use of chemicals such as herbicides and pests, chemical fertilizers, etc. or should be monitored for chemical contamination regularly to find ways to prevent.

Conclusion

Most of the times, the concentrations of Fe, Zn and Cd were found to exceed the water quality standards. Some water quality parameters have a negative correlation with Ba, Zn, Mn, Pb, Cr and As. Certain plankton species was negatively associated with Cd. Spottial needlefish was negatively associated with Mn. Thai river sprat was negatively associated with Zn. It indicates that heavy metals had negative effects on water quality, fish and plankton.

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