Abstract

As part of a larger study on land use in the Khun Samun watershed this study examines the environmental condition and relationships between land use intensity and environmental impacts. In order to carry out such a study a multidisciplinary approach, mainly within the natural sciences was adopted. Data expected to reveal status of river water quality was measured to the degree possible. A biological indicator key system was applied, to give more than a snapshot of the river condition. Soil sampling along the riverbank was conducted. These natural scientific methods were supplemented with background information on the land use practises, water uses and perceptions of the resident villagers.

There seem to be no serious problems with the environmental condition of the examined areas. Smaller changes in some indicators of water pollution is however detectable when comparing upstream to downstream. For the soil examinations no leaching from surrounding agricultural areas seemed to prevail. The main factor contributing to environmental impacts on the river is human settlement, as changes occur when the river passes the villages.

Our main constraints in the fieldwork were the limited time available. A considerably amount of time was spent within the intercultural and interdisciplinary group, however such a co-operation gave various advantages.

Appendix 7:
Pesticide residues measurement

Pesticide residues measurement										
Station	**Type of plants in the study area**									
	Location	orange	Cotton	Maize	Tama rind	Lychee	Passion fruit	pomelo	Upland rice	Water plants
4B	Ban Wang Tao	3	2	0	En	En	En	0	0	0
14	Ban Ka Sai	En	En	0	0	En	En	En	0	0
17B	Ban Hua Puk	En	En	0	En	En	En	En	0	0
19	Ban La Boa Ya	En	En	En	En	En	0	En	0	0
20	Ban La Boa Ya	En	En	0	En	0	En	En	0	0
26	Ban Hua Ra Pee	0	En	0	En	En	1	En	0	0
28	Ban Hau Hea	En	1	0	en	0	En	En	0	0

0 Non detectable
1 Low
2 Moderate
3 Higher than standard color
En No data

Appendix 6

Amount of bedload and suspended soid in Knun Samun River (on the button of river)

			Bed load in Knun Samun		
Sation	**location**	**Suspended soid mg/l**	**Sand %**	**Gravel %**	**Silt+clay %**
1	**1**	**60**	**82**	**10.845**	**7.155**
4B	**2**	**50**	**65.19**	**19.775**	**15.035**
14	**2**	**110**	**39.025**	**17.155**	**43.82**
20	**4**	**70**	**76.25**	**0**	**23.75**
26	**5**	**30**	**27.9**	**32.195**	**39.905**
27A	**5**	**40**	**51.915**	**27.195**	**20.89**
27B	**5**	**50**	**59.8**	**0**	**40.2**
28	**REF**	**50**	**69.13**	**0**	**30.87**
NEW	**3**	**40**	**56.35**	**0**	**43.65**

Percentage of different size of gravel in Knun Samun River (on the button of river)

station	**location**	**>4.5 mm%**	**>2 mm %**	**>1.00 %**	**>0.5 %**	**>0.25 mm %**	**<0.20mm %**
1	**1**	35.872	23.72	15.018	13.366	2.004	10.02
4B	**2**	62.33	21.34	9.156	3.168	2.584	1.422
NEW	**3**	71.786	11.23	4.778	4.078	6.32	1.808
14	**2**	6.958	28.698	48.35	10.942	0	5.052
17	**3**	61.83	20.192	12.09	0	4.78	1.108
20	**4**	5.946	35.4	47.138	9.772	0.526	1.218
26	**5**	86.842	9.166	1.848	0.39	0.34	1.414
27A	**5**	1.448	26.528	32.942	6.954	0.07	32.058
28	**REF**	72.37	23.88	2.078	1.102	0.626	-0.056

Appendix 5: Results from soil sampling

Soil texture, N, P, K and pH																
Station	Observations in field				Sediment analysis									Soil Test Kit		
	Humus layer (cm)	Topsoil (cm)	Topsoil color	Slope %	Soil dry weight	Sand (g)	Sand (%)	Silt (g)	Silt (%)	Clay (g)	Clay %	Texture (ft=finger test)	pH	NH_4	NO_3	P
1, Left	1	5	Brown	42	50,21	23,56	46,9	16,7	33,3	9,95	19,8	Loam	6	L	VL/L	M
1, Right	0	2	Brown	33	74,68	47,72	63,9	10,9	14,6	16,06	21,5	Sandy clay loam	.5 - 6.0	L	VL/L	M
4A, Left	0	0	Red brown	30	52,58	27,59	52,5	3,97	7,6	21,02	40,0	Sandy clay	6	VL/L	VL	M
4A, Right	0	10	Brown	38	51,06	37,91	74,2	10,14	19,9	3,01	5,9	Sandy loam	6	VL/L	L	M/H
4B, Left	0	7	Brown	17	51,58	32,99	64,0	16,14	31,3	2,45	4,7	Sandy loam	6	VL/L	L	M
4B, Right	0	6	Dark brown	32	51,92	24,36	46,9	4,65	9,0	22,91	44,1	Sandy clay	6	VL/L	VL/L	L
14, Left	0	12	Brown	32								ft=silty	6	L	VL	M/L
14, Right	0	5	Dark brown	32								ft=sandy	6	VL	L	L
17B, Left	0	14,5	Brown	18,5								ft=sandy loam	7	L	L	M/H
17B, Right	0	10	Light brown	16								ft=silt + loam	7	VL/L	VL	M/L
19, Left	2	11	Dark brown	37								ft=loamy soil	6-7	L	VL/L	M/L
19, Right	0	12	Brown	22								ft=Very varied	6-7	L	VL/L	M/L
20, Left	0,5	18	Dark brown	8								ft=gravel + stone	7	M/H	VL	H
20, Right	0	16	Light brown	16								ft=fine silt/coarse clay	7	VL/L	VL	M
26, Left	1	8	Brown	21								ft=clay+silt	6-7	L	VL/L	M/L
26, Right	0	0	Brown	27								ft=sandy	6-7	L	VL/L	M/L
27A, Left	0	5	Brown	10								ft=sandy	6-7	L	VL/L	M/L
27A, Right	1	0	Brown	2								ft=sandy	6-7	L	VL/L	M/L
27B, Left	1	4	Brown	2								ft=clay+gravel+stone	7	M	L	L
27B, Right	1	4	Brown	2								ft=silt +gravel	7	L	L	L
28, Left	1	3	Brown+red	20								ft=Clay+sand+gravel	7	VL/L	VL	M
28, Right	1	0	Brown	30								ft=caly+loam	7	L	L	L
Tiger, Left	1	10	Dark brown	19								ft	6	L	VL	VL/L
Tiger, Righ	0	10	Light brown	39								ft=sand + rock	6	VL	L	VL/L
Average	0,44	7,19		22,73												

K
L
L
L
L
L
M/L
L
L
L
L
L
L
L
L
L
L
L
L
L
L
L
L
L
L
L

Appendix 4: Complete physical and chemical water data

Sampling site	Physical parameters					Chemical parameters	
*=on Khun Samun	Temperature (^{o}C)	Turbidity (NTU)	Conductivity (mS/cm)	Velocity (m/s)	Flowrate (m^3/s)	pH	DO (mL/L)
1 *	26,0	29,80	0,120	0,52	0,59	7,69	8,40
3	26,5	25,20	0,123	0,29	0,02	7,03	3,70
4 A *	25,9	16,10	0,199	0,38	0,77	7,81	8,84
4 B *	26,6	32,20	0,203	0,33	1,42	7,90	7,86
5	30,0	20,90	0,198	0,36	0,02	6,96	5,45
9	27,2	29,70	0,135	0,12	0,05	7,32	6,14
11	26,6	13,90	0,162	0,22	0,06	7,80	8,25
12 *	25,6	15,90	0,202	0,80	1,12	7,68	8,57
13 *	26,8	18,00	0,211	0,89	1,08	7,96	8,63
14 *	26,8	15,70	0,212	0,69	0,87	7,97	8,30
15 A	26,5	9,70	0,163	0,22	0,03	7,32	7,70
15 B	25,7	5,90	0,197	0,08	0,01	7,39	7,77
17 A *	26,4	14,80	0,210	0,57	n.a.	7,98	9,56
17 B *	25,9	18,20	0,210	0,57	0,53	7,93	8,99
18	26,5	11,10	0,248	0,90	0,02	7,76	8,49
Tiger creek	26,2	10,10	0,199	0,22	0,08	7,78	8,76
19 *	25,9	24,37	0,190	1,48	1,49	7,81	8,68
20 *	25,5	17,63	0,187	1,20	0,97	7,80	8,20
21	25,2	10,30	0,280	0,36	0,04	7,78	8,20
22 *	24,9	15,20	0,185	0,44	0,55	7,79	8,16
23 A	n.a.						
23 B	24,4	16,40	0,210	0,46	0,03	7,45	7,50
24 *	24,0	16,10	0,200	1,44	1,4	7,81	8,44
25 A	26,5	19,70	0,190	0,52	0,04	7,70	7,37
25 B	n.a.						
26 *	25,9	16,20	0,060	0,34	0,77	7,90	7,51
27 A *	29,8	19,60	0,190	1,02	0,08	8,35	7,49
27 B *	30,0	49,50	0,090	0,50	0,04	7,87	7,23
28	25,0	11,30	0,160	0,69	1,11	8,00	8,58
29	28,3	4,12	0,050	n.a.	n.a.	5,93	5,80

Appendix 3:

QUESTIONNAIRE GROUP 6

Questions	High	Mode rate	Low	No
Usage of river				
1. Is there any usage of river from Khun Samun River Watershed or sub-watershed (branch/creek) for agriculture?				
2. Is there any usage of river from Khun Samun River Watershed or sub-watershed (branch/creek) for drinking?				
3. Is there any usage of river from Khun Samun River Watershed or sub-watershed (branch/creek) for household usage of water such as washing, cleaning, etc?				
4. Is there any fishing from Khun Samun River Watershed or sub-watershed (branch/creek) for Consuming?				
5. Is there any dropping waste into river?				
6. Is there any water treatment applied before draining into river?				
Farming system				
7. How much does herbicide being use?				
8. How much does fertilizer being use?				
9. How much does insecticide being use?				
10. Is there any application of machine in agriculture?				
11. Is there any livestock?				

12. Is there any cashcropping in the village? If yes, how important is it for the villagers livelihoods?				
Villagers perception of the problem				
13. In your opinion, how much does the village water pollution present?				
14. Is there any water shortage?				

17. * What kind of plantation grown in the field?

18. *How is the soil preparation pattern in the agricultural land?

19. * Is there any application of indigenous knowledge for water quality? How?

20. * Do you think whether the land use activities give the impact to water quality or not? Why?

21. * Is there any flooding occurred in the community?

*****Asking for "Crop calendar" from each group. *****

Thank ☺☺☺ You

Appendix 1: Description of sampling sites

Station no. 28:
Khun Samun river, upstream of Ban Huai Hua

GPS coordinates: 79186, 80799

Area description:
This station was intended to be used as a reference station. The river here is wide with fast flowing water, lots of big rocks and a lot of different niches. It is surrounded by forest (secondary), (bamboo, dense vegetation on left side) and there is no immediate signs of human disturbance, except from a small path along the river. The water is very clear.
The slopes from the riverbanks and 5m inland: Left bank: 20. Right bank: 30%.

Animals:
There was a lot of different types of animals, and it was very easy to catch and find them. The sizes of the animals was generally larger than downstream stations. Dominant species were stoneflies and mayflies. The identified species was:

Non-indicator-animals:
- Sucker Loach *(Homaloptera*). Small speciments
- Frogs and tadpoles
- Dragonflies and damselflies *(Odonata, Anisoptera and Zygoptera*)

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- Pea cockles *(Bivalvia, pisidium)*
- Freshwater snails *(Gastropoda, mainly Thiaridae*)
- Damselfly nymphs *(Odonata, Zygoptera):*
    - Balloontailed damselfly nymph (*Euphaeidae)*
    - ? *(Calopterygidae*)
    - Common damselfly nymph (?)
- Dragonfly nymphs *(Odonata, Anisoptera)*:
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Flattened mayfly nymph *(Heptageniidae*)
    - Burrowing mayfly nymph *(Ephemeridae)*
    - Prong-gilled mayfly (?)
    - Square-gilled mayfly (?)
- Stonefly nymphs (*Plecoptera):*
    - *Perlidae*

- Caddisfly larvae *(Trichoptera):*
    - Cased caddisfly larvae: Stone/gravel house (*Odontoceridae/Leptoceridae, Goeridae*) + stickhouses
    - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
- Dobsonfly larvae *(Megaloptera)*
- Waterbugs *(Hemiptera):*
    - lesser water boatman *(Notonectidae/Corixidae)*
- Pond skaters

Station no. 27A:
Huai Hua, upstream (reference area)

GPS coordinates: 70597, 93214

Area description:
The stream comes from forest are and the station is located about 5 minutes walk upstream of Ban Huai Hua.. On the left side there is a path and steep slope with sparse vegetation. On the right side there is a mixture of vegetation, older and younger trees, elephant grass, bamboo as well as a few bananapalms and mangotrees (Disturbed MDF). The stream is quite exposed to sunlight, as the right side of the riverbank is quite open. The stream is quite small and not very deep, but with fast flowing water. River bed is rocky and with gravel (hardly any mud).
The slopes from the riverbank and 5 m inland: Left bank: 10%. Right bank:13,5 %

Animals:
It was not as easy to find a lot of different animals in the river as it was at station 28. Probably due to a site with smaller habitat/niche diversity. There was however a lot of butterflies and dragonflies along the river.

Non-indicator animals found:
- Small fish (pelagic). Cannot be identified.
- Dragonflies and damselflies *(Odonata: Anisoptera and Zygoptera)*

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Freshwater snails *(Gastropoda, mainly Thiaridae*)
- Damselfly nymphs *(Odonata, Zygoptera):*
  - ? *(Calopterygidae*)
  - Common damselfly nymph (?)
- Dragonfly nymphs *(Odonata, Anisoptera)*:
  - One-tailed dragonfly nymph *(Gomphidae)*
  - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
  - Flattened mayfly nymph *(Heptageniidae*)
  - Burrowing mayfly nymph *(Ephemeridae)*
  - Prong-gilled mayfly nymph(?)
  - Square-gilled mayfly nymph(?)
  - Swimming mayfly nymph *(Baetidae)*
- Caddisfly larvae *(Trichoptera):*
  - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)

- Cased caddisfly larvae: Stone/gravel house (*Odontoceridae/Leptoceridae, Goeridae*) + stickhouses

- Water beetle larvae *(Coleoptera, Elminthidae)*
- Cranefly larvae *(Tipulidae)*
- Pond skaters

Station 27B:

Downstream Huai Hua, before junction with Khun Samun

GPS coordinates: 71257, 93615

Area description:

Still a rather small stream, situated just after Ban Huai hua. No major tress, a lot of elephant grass , also maize and vegetables on the (traces of burning), along with a few bananapalms. The area is quite flat, short steep sides around the river. Human settlement close to station
The slopes from the riverbank and 5m inland: Left bank: 1-2%. Right bank: 11-2%

Animals:

A lot of crabs and shrimps of big sizes.

Non-indicator animals:

- small fish, Honey Sucker (gyrinocheilus aymonieri)
- Freshwater snails (smaller than 15mm), *(Gastropoda, mainly Thiaridae*)

Indicator animals:

- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- Pea cockles *(Bivalvia, pisidium)*
- Damselfly nymphs *(Odonata, Zygoptera):*
    - ? *(Calopterygidae*)
    - Common damselfly nymph (?)
- Dragonfly nymphs *(Odonata, Anisoptera)*:
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Prong-gilled mayfly (?)
    - Square-gilled mayfly (?)
- Alderfly larvae (?)
- Water beetle larvae *(Coleoptera, Elminthidae)*
- Pond skaters

Station 26:
Khun Samun, before junction (Huai Lak Phi and Khun Samun)

GPS coordinates: 72314, 92117

Area description:
The river is quite deep. It is situated in a forest area, with teak- and fruit tree plantations on one side of the river and grass on the other. The river here is more muddy than 27A, 27B and 28. There is a lot of shade around the river, and quite a lot of different niches along the sampling area.
Slopes from river bank and 5 m inland: Left bank:21%, Right bank: 27%.

Animals:
A lot of small fish were observed in the water. There were also many butterflies and dragon- and damselflies.

Non-indicator animals:
- Frogs and tadpoles
- Dragonflies and damselflies *(Odonata, Anisoptera and Zygoptera*)
- Freshwater snails *(Gastropoda, mainly Thiaridae*)

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae)*
- Pea cockles *(Bivalvia, pisidium)*
- Swan mussels *(Bivalvia, ?)*
- Dragonfly nymphs *(Odonata, Anisoptera)*:
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Flattened mayfly nymph *(Heptageniidae*)
    - Burrowing mayfly nymph *(Ephemeridae)*
    - Prong-gilled mayfly (?)
    - Swimming mayfly nymphs *(Baetidae)*
- Waterbugs *(Hemiptera):*
    - lesser water boatman *(Notonectidae/Corixidae)*
    - Other waterbugs: Water stick insect (nepidae)
- Water beetle larvae *(Coleoptera, Elminthidae)*
- Pond skaters

Station no. 25A:
Huai Lak Phi

GPS coordinates: 72401, 91659

Area description:
Small stream. Situated right next to the dirt road. Not a lot of shade around river

Only physical and chemical data measured at this station!

Station no. 24:
Khun Samun, after junction of Huai Lak Phi and Khun Samun

GPS coordinates: 73057, 91806

Area description:
On the left bank there are maize fields. On the right bank Upland rice. The river is wide, and it is difficult to collect biological data at this site.

Only physical and chemical data measured at this station!

Station no. 23B:
Creek reference

GPS coordinates: 73768, 91175

Area description:
The riverbank is covered with mixed deciduous forest down to Khun Samun river

Only physical and chemical data measured at this station!

Station no. 22:
Khun Samun, upstream of Ban La Bao Ya, after junction of KS. and Huai Muang

GPS coordinates: 75032, 92055

Area description:
Wide river with a lot of butterflies

Only physical and chemical data measured at this station!

Station no. 21:
Huai Muang, reference.

GPS coordinates: 75034, 92206

Area description:
Upland rice is grown along the stream. Surrounded by gravel and coarse sand. Water looks clear.

Only physical and chemical data measured at this station!

<u>Station no. 20:</u>

<u>Khun Samun, upstream of Ban La Bao Ya after junction with Huai Muang</u>

GPS coordinates: 76729, 91142

Area description:

Forest surroundings, a lot of vegetation along the riverbank, among others big bamboo. Litchi plantation on the upper bank. The river bottom is not as muddy as station no. 26. The stream is medium deep, with a high variety of different niches. The slopes from river bank and 5m inland: Left bank:8%, Right bank: 16%

Animals:

There was a lot of caseless caddisfly larvae and many mayflies. This was also the first station were red worms were found for the first time.

Non-indicator animals:

- Small fish (juvenile), Honey Sucker (gyrinocheilus aymonieri)
- Freshwater snails (smaller than 15mm), *(Gastropoda, mainly Thiaridae)*
- Tadpoles

Indicator animals:

- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Pea cockles *(Bivalvia, pisidium)*
- Freshwater snails (larger than 15mm), *(Gastropoda, mainly Thiaridae*)
- Dragonfly nymphs *(Odonata, Anisoptera)*:
  - One-tailed dragonfly nymph *(Gomphidae)*
  - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
  - Burrowing mayfly nymph *(Ephemeridae)*
  - Prong-gilled mayfly (?)
  - Square-gilled mayfly (?)
- Stonefly nymphs (*Plecoptera):*
  - *Perlidae*
- Caddisfly larvae *(Trichoptera):*
  - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
- Segmented worms (Oligochaeta) (Small red ones, more than 15 body segments)
- Adult beetles (Coleoptera) 2 types found.
- Cranefly larvae *(Tipulidae)*
- Pond skaters

Station no. 19:

Khun Samun, downstream of Ban La Bao Ya before junction of Huai Heat and Khun Samun

GPS coordinates: 76581, 91142

Area description:

Maize fields in the surrounding areas, quite steep slopes, with Litchi and upland rice fields further up. Yet, there was a certain buffer zone vegetation just around the river, consisting of a mixture of older and younger trees, bamboo, shrubs and so on.
The stream itself had rocky/stony bottom and was rather large.
The slopes from riverbank and 5 m inland: Left bank:35-40%. Right bank: 22%

Animals:

In this station quite a lot of red worms were found.

Non-indicator animals:

- Butterflies
- Freshwater snails *(Gastropoda, mainly Thiaridae*), smaller than 15mm.

Indicator animals:

- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- **Pea cockles *(Bivalvia, pisidium)***
- Dragonfly nymphs *(Odonata, Anisoptera)*:
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Flattened mayfly nymph *(Heptageniidae*)
    - Prong-gilled mayfly nymph(?)
    - Swimming mayfly nymph *(Baetidae)*
- Caddisfly larvae *(Trichoptera):*
- Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
- Stonefly nymphs (*Plecoptera):*
    - *Perlidae*
- Cranefly larvae *(Tipulidae)*
- Segmented worms *(Oligochaeta)* (Small red ones, more than 15 body segments)
- Pond skaters

Station no. 18:
Huai Heat. Reference

GPS coordinates: 76976, 91232

Area description:

It was necessary to cross a small bamboo bridge. The stream was still quite small compared to Khun Samun. On the left bank there was a litchi orchard. The area looked very nice, with many insects (butterflies and dragon- and damselflies.).

Only physical and chemical measurements at this station!

Station no. 17B:
Khun Samun, after junction (Khun Samun and Huai Heat)

GPS coordinates: 76893, 91067

Area description:
The stream here is pretty wide, and appears to be in a very good condition. On the left bank there is a newly burned field, with newly planted maize. Vegetable, banana and fruittrees was observed as well. The stream itself comes from very dense tree vegetation.
The slopes of riverbank and 5m inland: Left bank: 18-19%. Right bank: 16%

Animals:
A lot of animals were observed on the riverbank, including frogs, butterflies, and dragonflies. In the river itself, a lot of animals were found. The shrimps found were quite big.

Non-indicator animals:
- tadpoles and frogs
- butterflies
- Dragonflies and damselflies *(Odonata, Anisoptera and Zygoptera*)

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- Pea cockles *(Bivalvia, pisidium)*
- Swan mussels *(Bivalvia, ?)*
- Damselfly nymphs *(Odonata, Zygoptera):*
    - Balloontailed damselfly nymph (*Euphaeidae)*
    - ? *(Calopterygidae*)
    - Common damselfly nymph (?)
- Dragonfly nymphs *(Odonata, Anisoptera)*:
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Flattened mayfly nymph *(Heptageniidae*)
    - Burrowing mayfly nymph *(Ephemeridae)*
    - Prong-gilled mayfly nymph(?)
    - Square-gilled mayfly nymph(?)
    - Swimming mayfly nymph *(Baetidae)*
- Stonefly nymphs (*Plecoptera):*
    - *Perlidae*
- Caddisfly larvae *(Trichoptera):*

- Caseless caddisfly larvae: *(Hydropsychidae*, *Philopotamidae*, *psychomyiidae*)

- Dobsonfly larvae *(Megaloptera)*
- Adult beetles (Coleoptera) 2 types found.
- Cranefly larvae *(Tipulidae)*
- Pond skaters

Station no. 17A:
Khun Samun, upstream of Ban Huai Puk

GPS coordinates: **77367, 90251**

Area description:
Plans about dam construction as Ban Huai Puk lacks water for agricultural purposes

Only physical and chemical measurements at this station!

Station no. 15B:
Huai Puk, downstream

GPS coordinates: **77752, 89434**

Area description:
First impression of this site was that it was in a very good condition. Many damsel- and dragonflies, also many butterflies. Very nice.

Only physical and chemical measurements at this station!

Station no. 15A:
Huai Min

GPS coordinates: **77753, 89096**

Area description:
The stream is small. The is a farmer resevoir, and station is by roadbridge.

Only physical and chemical data measured at this station!

Station no. 14:
Khun Samun, upstream of Ban Kasai and downstream of Ban Huai Puk.

GPS coordinates: 76765, 87105

Area description:
First impression: nice looking stream with a lot of shade from surrounding buffer vegetation (quite dense). Tree vegetation along the riverbank and slopes. Human settlement on left side slope. Small waste dump (hole), and a primitive toilet on top of the slope.
Right side of the bank was covered with grass and bamboo.
The slopes from river bank and 5m inland: Left side:32%. Right bank: 32%

Animals:
Quite a lot of small molluscs were found

Non-indicator animals:
- Butterflies
- Freshwater snails *(Gastropoda, mainly Thiaridae*), smaller than 15mm.

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- Pea cockles *(Bivalvia, pisidium)*
- Damselfly nymphs *(Odonata, Zygoptera):*
  - ? *(Calopterygidae*)
  - Common damselfly nymph (?)
  - Thicktailed damselfly nymph
- Dragonfly nymphs *(Odonata, Anisoptera)*:
  - One-tailed dragonfly nymph *(Gomphidae)*
  - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
  - Flattened mayfly nymph *(Heptageniidae*)
  - Burrowing mayfly nymph *(Ephemeridae)*
  - Prong-gilled mayfly nymph(?)
  - Square-gilled mayfly nymph(?)
  - Swimming mayfly nymph *(Baetidae)*
- Stonefly nymphs (*Plecoptera):*
  - *Perlidae*
- Caddisfly larvae *(Trichoptera):*
  - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
  - Cased caddisfly larvae: Stone/gravel house (*Odontoceridae/Leptoceridae, Goeridae*) + stickhouses

- Adult beetles (Coleoptera) 2 types found.
- Water beetle larvae *(Coleoptera, Elminthidae)*
- Other fly larvae
- Segmented worms (*Oligochaeta*), red.
- Pond skaters

Station no. 13:
Khun Samun, before junction (Huai Kasai and Khun Samun)

GPS coordinates: 76928, 86334

Area description:
This station was located among the villagers (Ban Kasai)

Only physical and chemical data measured at this station!

Station no. 12:
Khun Samun ??

GPS coordinates: 7724484657

Area description:
Sandy soils with clay. Quite fertile

Only physical and chemical data measured at this station!

Station no. 11:
Huai Ka Sai

GPS coordinates: 76074, 85842

Area description:
None

Only physical and chemical data measured at this station!

Station no.9:
Huai Pong Pan

GPS coordinates: 78142, 84229

Area description:
The stream at this site was surrounded by paddy fields. The measured DO was low. Chok got itchy arms after contact with the water.

Station no. 5:
Huai Thalu

GPS coordinates: 79310, 82207

Area description:
None

Only physical and chemical data measured at this station!

Station no. 4B:
Khun Samun, downstream of Ban Wang Tao

GPS coordinates: 78720, 83123

Area description:
This station is located just after human settlement. The river has now changed colour to a light brownish, the bottom has become quite muddy (not stony and rocky anymore). Cotton fields up the right bank, and bamboo and forest along the bank. Bamboo and fruit tree plantation on the left bank. Signs from livestock (footprints) along the river. Still quite a lot of buffer vegetation along the river bank.
The slopes from riverbank and 5 m inland: Left bank:17%. Right bank: 32%

Animals:
Red worms found again. Non-biting midge larvae found for the first time.

Non-indicator animals:
- butterflies

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae*, *Palaemonidae*)
- Damselfly nymphs *(Odonata*, *Zygoptera):*
  - Thick-tailed damselfly nymph
- Dragonfly nymphs *(Odonata, Anisoptera)*:
  - One-tailed dragonfly nymph *(Gomphidae)*
  - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
  - Flattened mayfly nymph (*Heptageniidae*)
- Other waterbugs:
  - Water stick insect *(nepidae)*
- Segmented worms (*Oligochaeta*), red.
- Non-biting midge larvae, red (*Chironimidae)*
- Pond skaters

Station 4A:
Khun Samun, upstream of Ban Wang Tao

GPS coordinates: 77749, 83800
Area description:
Immediate impression: A lot of signs of human disturbance, even though there still is a buffer vegetation of forest like vegetation present. Garbage lying around (bottles and plastic). The river bottom is rocky, but there is a layer of mud covering it. There is also signs of livestock near the water. On the nearby fields, teak- and orange orchards. Also bamboo.
The slopes from river bank and 5m inland: Left bank:30%. Right bank: 38%

Animals:
A lot red worms were found. Also large snails. Dragonflies were the dominant species.

Non-indicator animals:
- Juvenile fish, Flying minnow (Esomus metallicus)
- Butterflies
- Tadpoles
- Small pond snails *(gastropoda)*

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Pea cockles *(Bivalvia, pisidium)*
- Freshwater snails (larger than 15mm), *(Gastropoda, mainly Thiaridae*)
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- Damselfly nymphs *(Odonata, Zygoptera):*
    - Thick-tailed damselfly nymph
- Dragonfly nymphs *(Odonata, Anisoptera)*:
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Flattened mayfly nymph *(Heptageniidae*)
    - Burrowing mayfly nymph *(Ephemeridae)*
    - Swimming mayfly nymph *(Baetidae)*
- Caddisfly larvae *(Trichoptera):*
    - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
- Cranefly larvae *(Tipulidae)*
- Other waterbugs:
    - Water stick insect *(nepidae)*
- Other fly larvae
- Segmented worms (*Oligochaeta*), red.
- Non-biting midge larvae, red (*Chironomidae)*
- Pond skaters

Station no. 3:

Huai Kaow (downstream), before junction (Huai Kaow and Khun Samun)

GPS coordinates: 78844, 82764

Area description:

None

Only physical and chemical data measured at this station!

<u>Station no. 1:</u>
<u>Outlet of Khun Samun</u>

GPS coordinates: 79186, 80799

Area description:
The river looks quite turbid (brown-orange colour). Buffer vegetation on riverbanks of mixed tree types, many bamboo (leavy ground). Exposed riverbank very muddy and slippery. Rice field up the river bank.
The slope of the river banks and 5m inland: Left bank:40-45%. Right bank:33%

Animals:
Very difficult to find the invertebrates. Very few species, some of them dead (crabs and empty shells from molluscs).
Red worms found

Non-indicator animals:
- None observed

Indicator animals:
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae*)
- Pea cockles *(Bivalvia, pisidium)*
- Freshwater snails (larger than 15mm), *(Gastropoda, mainly Thiaridae*)
- Damselfly nymphs *(Odonata, Zygoptera):*
- Dragonfly nymphs *(Odonata, Anisoptera)*:
  - One-tailed dragonfly nymph *(Gomphidae)*
  - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
  - Flattened mayfly nymph *(Heptageniidae*)
  - Swimming mayfly nymph *(Baetidae)*
- Caddisfly larvae *(Trichoptera):*
  - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
- Other waterbugs:
  - Water stick insect *(nepidae)*
- Other fly larvae
- Adult beetles (Coleoptera) 2 types found.
- Segmented worms (*Oligochaeta*), red.
- Pond skaters
-

<u>Station:</u>

<u>Huai Sua (Tiger Creek)</u>

GPS coordinates: 77509, 90315

Area description:

Evidence of livestock near the river. Funny smell around river in some places. Otherwise nice impression of small, stony stream, with a lot of shrub, tree buffer vegetation. Bamboo. Right bank up: vegetable, banana, casava.
Slopes from river banks and 5m inland: Left bank: 19%. Right bank: 39%

Animals:

Long white hairworm found. Many spiders on riverbank.

Non-indicator animals:

- hairworm
- butterflies
- Dragonflies and damselflies
- Juvenile fish (bottom fish)
- Tadpoles

Indicator animals:

- Freshwater snails (larger than 15mm), *(Gastropoda, mainly Thiaridae*)
- River shrimps or prawns *(Order: Decapoda. Caridae, Palaemonidae***)**
- Freshwater crabs *(Decapoda, Potamidae and Parathelphusidae*
- Damselfly nymphs *(Odonata, Zygoptera):*
    - Thick-tailed damselfly nymph
- Dragonfly nymphs *(Odonata, Anisoptera*):
    - One-tailed dragonfly nymph *(Gomphidae)*
    - Common dragonflies (?)
- Mayfly nymphs *(Ephemeroptera):*
    - Flattened mayfly nymph *(Heptageniidae*)
    - Burrowing mayfly nymph *(Ephemeridae)*
    - Swimming mayfly nymph *(Baetidae)*
- Stonefly nymphs (*Plecoptera):*
    - *Perlidae*
- Caddisfly larvae *(Trichoptera):*
    - Caseless caddisfly larvae: *(Hydropsychidae, Philopotamidae, psychomyiidae*)
- Cranefly larvae *(Tipulidae)*
- Beetle larvae *(coleoptera)*
- Other fly larvae
- Segmented worms (*Oligochaeta*), red.
- Non-biting midge larvae, red (*Chironomidae)*
- Pond skaters

<u>Station:</u>

Forest area creek

GPS coordinates: 671121, 94091

Area description:
Very clear water, dense forest. Small waterfall

Only physical and chemical data measured at this station!

Station:
Lateral flow of the headman assistant

GPS coordinates: 71123, 94255

Area description:
This is a water coming directly from an underground spring. The assistant headman has a pipeline from this down to his house.
He grows cotton on the riverbank slope.

Only physical and chemical data measured at this station!

Appendix 8:

Answers to questionnaires

Usage of river

Question	**Range**	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**
1. Is there any usage of river from Khun Samun River Watershed or sub-watershed (branch/creek) for agriculture?	**High**					
	Moderate	X	X	X		X
	Low				X	
	No					

All villages use water from Khun Samun for agriculture

Question	**Range**	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**
2. Is there any usage of river from Khun Samun River Watershed or sub-Watershed (branch/creek) for drinking?	**High**					
	Moderate					
	Low					X
	No	X	X	X	X	

From Huai Hua and Khun Samun only location 5 use water for drinking in dry season

Question	**Range**	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Group 5**
3. Is there any usage of river from Khun Samun River Watershed or sub-watershed (branch/creek) for household usage of water such as washing, cleaning, etc?	**High**	X				
	Moderate					
	Low					
	No		X	X	X	X

Villagers use mountain pipelines for households a lot more than water from Khun Samun

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
4. Is there any fishing from Khun Samun River Watershed or sub-watershed (branch/creek) for Consuming?	**High**					
	Moderate					
	Low	X	X	X		
	No				X	X

Only very little fishing in Khun samun. Use ponds instead. Villagers increase productiontion of fish instead of overfishing.

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
5. Is there any dropping waste into river?	**High**				X	
	Moderate	X				
	Low					
	No		X	X		X

Pig excretion in river.
There are more pig excretion and garbage dump from location 4 than from other locations. In general villagers complain about upstream villages.

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
6. Is there any water treatment applied before draining into river?	**High**					
	Moderate					
	Low	X	X	X	X	X
	No					

No waste water treatment in any villages before dropping into river.

Farming system

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
7. How much does herbicide being use?	**High**	X	X	X	X	X
	Moderate					
	Low					
	No					

In general a lot of herbicides is being used throughout watershed

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
8. How much does fertilizer being use?	**High**					
	Moderate		X		X	X
	Low	X		X		
	No					

Use of fertilizer is low-moderate for all villages
NB: no distinction between crop types in our method

NB: money is key constraint for fertilizer use

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
9. How much does insecticide being use?	**High**					X
	Moderate					
	Low	X	X	X	X	
	No					

In general not much insecticide is being used. It depends on crop type. In location 5 lot of cotton is grown and therefore more insecticide.
NB: large drop in bio-indicator af location 5.

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
10. Is there any application of machine in agriculture?	**High**					
	Moderate	X				
	Low		X	X		X
	No				X	

If agricultural machinery is being used as an indicator of intensification, then we see that agricultural intensification increases downstream…..hypothesis supported………Maybe sign of high/low accessibility….infrastructure.

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
11. Is there any livestock?	**High**				X	
	Moderate	X	X			
	Low			X		X
	No					

In general much livestock. Most in location 4 because of believes.
NB: Raise in turbidity after location 4

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
12. Is there any cashcropping in the village? If yes, how important is it for the villagers livelihoods?	**High**	X	X	X		X
	Moderate					
	Low				X	
	No					

High degree of cash cropping except location 4. Mien belief: rice+maize grown for own consumption.
Amount of cash cropping NOT dependent on distance to Nan.

Villagers perception of the problem

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
13. In your opinion, how much does the village water pollution present?	**High**				X	
	Moderate	X	X	X		
	Low					X
	No					

Villagers know that river is polluted, but sometimes use it in order to survive. Location 3 complains about location 4.

Question	Range	Group 1	Group 2	Group 3	Group 4	Group 5
14. Is there any water shortage?	High			X		
	Moderate					
	Low	X	X			
	No				X	X

Water shortages for location 3….but not water from Khun Samun.

List of Contents

1. INTRODUCTION

River systems around the world are important in many aspects. They are a source of water, food, and hydropower and provide a host of other ecosystem services, from water purification and retention to flood control to nutrient recycling – vital to human civilisations (Revenga *et al.*, 1998). Given the ecological importance of watersheds and the extent of human dependence on the services provided by them, watershed degradation has potentially enormous environmental and socio-economic costs.

The two main sources of human influence on most Asian streams and river ecosystems are land modification for crop cultivation and river regulation and control (Dudgeon, 1992). Many human activities produce by-products, some known as pollutants, and discharge them into the environment. This can be nutrients from fertilizers or it can be household sewage, animal wastes, or agricultural chemicals (Huang & Xia, 2001). Besides from the direct effects this have on the terrestrial environment, it will potentially also has an impact on the aquatic environment, the river, altering biological, chemical and physical properties.

In the case of the Khun Samun watershed, the overall hypothesis for the SLUSE project 2001 is that land use intensifies the closer the villages – and therefore the river – are to Nan city. Intensification normally means a larger input of some of the pollutants mentioned above, and a higher degree of alteration of land for agricultural purposes. Such an alteration will often have an impact on river water quality and another hypothesis could therefore be that water quality will deteriorate from upstream to downstream the research area.

The Khun Samun River runs through (or very close by) all of the five villages in the study area. Hence, a change in the factors that determine the quality of the water will affect both human life and the natural environment of all the villages. This is also the reason why the main focus of this study will be on the Khun Samun River. Therefore the overall research question is:

Is there a relationship between land use intensity and environmental condition of the Khun Samun Watershed?

The two main objectives in this regard are:

- To study potential environmental impacts on the Khun Samun Watershed, with point of departure in the river.
- To study relationships between land use intensification and river water-quality.

As environment consist of many different elements, it has been necessary to define environmental condition into four major elements: Water-quality, soil-quality and air-quality. The latter was however not possible to include, as data collection would not have been possible and no secondary data for the specific area was available.

Other factors, such as natural vegetation cover, wildlife and many others, are also important elements of an environmental system, but this study is narrowed down to a main focus on the immediate river system for a number of reasons: First of all the limited time made it unrealistic to make a full survey of all elements. The river system was chosen as a main focus, since it is a system that runs through all the five villages targeted in the overall project, and therefore any changes and impacts on this system will affect all the villagers, since the villages all are situated close by the rivers, and all use the water for a variety of purposes. For the latter mentioned reasons, it is also important to get an overview of the villagers different uses of the water resource, their perception and opinion on potential problems related to the river system and also their land use systems and practices. This is a final and important element in the study of environmental impacts.

For reasons mentioned above the main focus is on the main river (Khun Samun River) and on issues related to water-quality in particular, which also means an examination of the areas soil properties. A water- and soil- quality assessment consists of an evaluation of the physical, chemical and biological nature of water and soils in relation to natural quality, human effects and intended uses, particularly uses which may affect human health and the health of the ecosystem itself (UNEP *et al.*, 1992).

This study will begin with an overview of the methods applied, in the attempt to gather all these data and information. They consist of mixture of typical natural scientific methods, such as measurement of chemical water properties, soil sampling etc. It was also attempted to retrieve as much possible information on the villagers' socio-economic status and their uses of the river as a resource, through interviewing the other SLUSE groups, working in the villages. These data were collected to form a background, and also to give relevance to results obtained concerning the environmental condition of the watershed, and put these results into a wider perspective than a purely natural scientific one.

The obtained relevant data will be presented and analysed, and a discussion on the results will follow. The methods applied and their relevance will also be discussed and finally conclusions drawn.

1.2 Introduction to the River System

Khun Samun watershed is located within a sub-humid tropical zone and the major influences are the southwest and the northwest monsoons. The watershed is a sub-watershed within the Nan Basin. It is about 21 km from Nan city and covers an area of about 128 km^2. There are three seasons; a rainy season (August-September), a cool season, which begins around mid-October and last until mid-February, and a hot and dry season from mid-March onwards (Traynor *et al.*, 2001). The total annual rainfall is 1259.7 mm, with a total of 82.6 mm in October, which was the time the fieldwork was carried out (Nan Agronomic Research Station files, 2001 cf. Traynor *et al*., 2001).

Like other areas in Nan province, a lot of the vegetation consists of dry evergreen and mixed deciduous forest, especially in the most northern parts. The forest cover is estimated to bee approximately 30 %. Vegetation strips were observed especially along the rivers. These patchy trees are expected to have a substantial role in supporting the aquatic ecosystem function within the catchment. Also these "buffer-zone" vegetation strips can act as barriers for preventing excessive surface runoff from the croplands. These riparian vegetation corridors are mainly deciduous and dry evergreen trees and also different type of shrubs (Traynor *et al*., 2001; field observations, 2001).

The Khun Samun River is receiving water from more than 10 small streams that originate from the high mountains in the northeast and flow downwards into the Nan River in the Southwest. Some of the side-streams are perennial, but most lack waterflow in the dry season

(Khun Samun Watershed Management Unit, 2000 cf. Traynor *et al*., 2001). The Khun Samun main river has a flow rate that varies down through the watershed, with a maximum flow rate of 1.49 m^3/s and an average of 0.83 m^3/s at the time of measurement in October. Upstream, the water is generally very clear, with a rocky and stony bottom and a diverse appearance. Further downstream the river is less meandering, murkier and with a growing layer of silt and mud covering the rocky bottom. It is also wider and has a less diverse appearance (field observations, 2001).

2. METHODOLOGY

The data needed to investigate the river water-quality consists of a variety of different parameters. A multi-disciplinary approach within the natural sciences is necessary because issues and the impact of measures may have physio-chemical, biological, hydrological and ecological components. As mentioned it should also be supplemented by social scientific research, to get the overall picture.

In practise and on an overall level this was accomplished by working in interdisciplinary teams. Since this particular study was intended to be mainly of natural scientific nature, the Danish team consisted of two agronomists and one biologist. The interdiscplinarity between natural- and other sciences is therefore mainly expressed, when the SLUSE project as a whole is considered. Besides from the interdisciplinary nature of the study, it also involves inter-cultural cooperation, both with fellow Thai students and with the people living in the area, subject to the study.

We didn’t divide our group into three sub-teams (A, B and C teams) like the other SLUSE working groups, but worked more fluently sharing responsibilities between group members on all issues.

We divided our fieldwork into 7 main steps:
Selection of sampling sites
Collection of physical and chemical parameters for water
Collection of biological indicators at some of the sampling sites

Collection of sediment, plant samples and soil samples along the river bank at some of the sampling sites

Identification of biological indicators and tests of soil, sediment and plant samples

Interview with each group concerning usage of water from Khun Samun

Data analysis and conclusion

These steps present the overall way of the fieldwork process. The steps are not followed consequently in the report, but parts of them can be recognized in the methodology and discussion sections

2.1 Sampling Site Selection

First of all the five villages were visited and observed from upstream to downstream of Khun Samun watershed. Then selecting sampling sites were necessary directly from the map. Finally selecting each sampling sites in the field and marked with Geographic Positioning System (GPS).

Sampling sites were selected at the Khun Samun River just before and after junctions with side-streams. Furthermore sampling sites at the side-streams were selected just before junction with Khun Samun. Sampling sites before and after the river was running through each village were also selected. Some sampling sites for reference measures were selected upstream of side streams and upstream Khun Samun. Figure 1 shows a map of Khun Samun watershed including villages and sampling sites along the river system. For a detailed description of each sampling site, refer to appendix 1.

Referring to the map and using GPS in the field along Khun Samun watershed we selected 25 sampling sites for identifying the water quality and 4 sampling sites for references from upstream of Khun Samun watershed. The purpose of selecting sampling sites before and after junctions with the side streams, sampling sites before and after each village and sampling sites for references was to compare the water quality of the river for each village to the reference site.

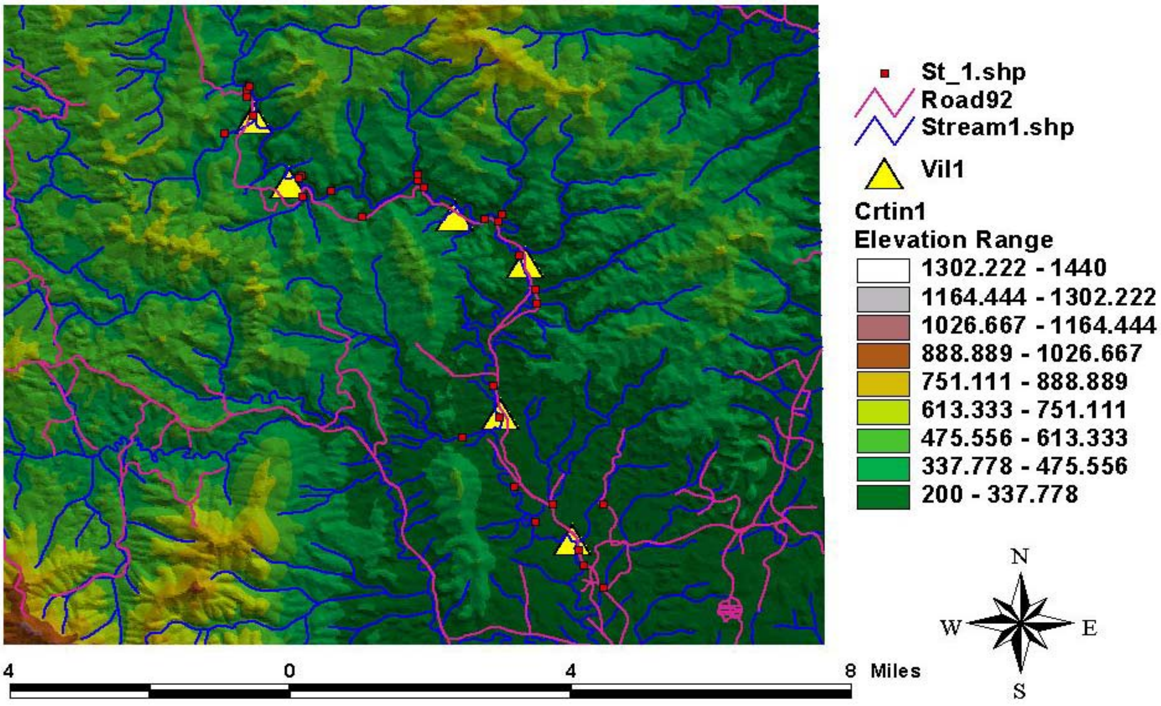


Figure 1: Sampling stites along the river system marked with squares. Villages marked with triangles.

2.2 Physical and Chemical Data Collection

Water quality parameters frequently tested in relation to stream and river monitoring are of a chemical and physical nature. Most of the parameters are related to each other, for example there is a relationship between temperature and dissolved oxygen. The physio-chemical parameters important when estimating the water-quality of rivers are described in the table 1.

Table 1: Physio-chemical variables/indicators:

Parameter	Justification
Dissolved oxygen (DO) (mg/L)	Animals require oxygen for respiration and there is a pronounced relationship between oxygen concentration and growth rate and mortality. Low oxygen concentrations in aquatic ecosystems have often caused the destruction of fish and other smaller aquatic fauna due to discharge of otherwise harmless organic material, which is biologically decomposed by micro-organisms. At least 6 mg O^2/L is needed for many fish species. Oxygen concentration is influenced by

	several factors, of which the most important are the decomposition of organic matter, nitrification of ammonia, photosynthesis etc. (Jørgensen, 2001).
Temperature (°C)	Temperature is also of great importance to aquatic ecosystems and is linked to oxygen concentration. When temperatures are high, biological degradation is high (large consumption of oxygen) and oxygen solubility is low.
Turbidity (NTU)	Turbidity refers to how clear the water is. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears and the higher the measured turbidity. Turbidity is a standard measurement in stream sampling programs where suspended sediment is an extremely important factor to monitor. Sources of turbidity can be phytoplankton, clays and silt from riverbank erosion, re-suspended bottom sediment and organic detritus from e.g. wastewater discharges. High concentrations can modify light penetration, smother benthic habitats - impacting both organisms and eggs. If light penetration is reduced significantly, macrophyte growth may be decreased which could in turn impact the organisms dependent upon them for food and cover. Reduced photosynthesis can also result in lower daytime release of oxygen into the water. Turbidity is reported in nephelometric units (NTUs) which refers to the type of instrument used (turbidimeter or nephelometer) used for estimating light scattering from suspended particulate material. Turbidity can be used to estimate the TSS. TSS is a parameter that directly relates to land uses in the watershed. Pollution tends to reduce water clarity. Watershed development and poor land use practises cause increases in erosion, organic matter, and nutrients, all of which cause increases in suspended particulates and algae growth.
Biochemical oxygen demand (BOD5) (mg/L)	Pollution with organic material (waste water etc.) is reflected in a high oxygen consumption- BOD5- which is the amount of oxygen micro-organisms consume by decomposing the organic material over 5 days at 20°C.

pH	The pH determines the solubility and the biological availability of chemical constituents such as nutrients and heavy metals. E.g. metal, tend to be more toxic at lower pH because they are more soluble. When pollution results in higher algal and plant growth (e.g., from increased temperature or excess nutrients), pH levels may increase. Although these small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms in river and may aggravate nutrient problems.
Electrical conductivity (EC) (µS/cm)	EC estimates the amount of total dissolved solids (TDS), or the total amount of dissolved ions in the water. It can be used to as rough indicators of mineral salt content (Na^+, Ca^{++}, K^+, Mg^{++}, SO_4^{2-}, Cl^-, HCO_3^-) when measurement of each dissolved ion cannot be made. There are a number of sources of pollutants which may be signalled by increased EC: -Wastewater from septic systems and disposal systems, - Agricultural run-off of water draining fields typically has high levels of dissolved salts. Although a minor fraction of the TDS - nutrients (Ammonium-nitrogen, nitrate-nitrogen and phosphate from fertilizers) and pesticides typically have significant negative impacts on streams receiving agricultural drainage water. The units for electrical conductivity are microSiemens per centimetre.
Suspended solids (SS) (mg/L)	Suspended solids concentrations and turbidity both indicate the amount of solids suspended in the water, whether mineral (e.g. soil particles) or organic (e.g. algae). However, the SS test measures an actual weight of material per volume of water, while turbidity measures the amount of light scattered from a sample (more suspended particles cause greater scattering). High concentrations of particulate matter can cause increased sedimentation and siltation in a stream, which in turn can destroy important habitat areas for aquatic life. Suspended particles also provide attachment places for other pollutants, such as metals and bacteria. High suspended solids or

	turbidity readings thus can be used as “indicators” of other potential pollutants. Land use is probably the greatest factor influencing changes in SS (or turbidity) in streams. As watersheds develop, there is an increase in disturbed areas (e.g. cropland, human settlement), a decrease in vegetation, and increases in rates of run-off. These all cause potential increases in erosion, particulate matter, and nutrients, which in turn promote increased algae growth. For example, loss of vegetation in general exposes more soil to erosion, allows more run-off to form, and simultaneously reduces the watershed’s ability to filter run-off before reaching the stream.
Nutrient content (P and N) (mg/L)	Increased nutrient concentrations are almost always an impact of pollution. The nutrients can come from the same sources as coliform bacteria. Agricultural areas can also contribute to nutrient increases through poor manure and fertilizing practices and increased erosion from ploughed surfaces.
Coliform Bacteria (MPN/L)	Faecal coliform bacteria are microscopic organisms that live in the intestine of warm-blooded animals. They also live in waste material, or faeces. When faecal coliform bacteria are present in high numbers in a water sample, it means that the water has received faecal matter from one source or another. The primary sources of faecal coliform bacteria to fresh water are wastewater treatment plant discharges, failing septic systems, and animal waste.
Pesticide content	Affects aquatic life, direct human uses of water.
Water velocity, stream depth and width	These parameters are part of an overall physical characterization of the river. They are important for turbulence and the animals that inhabit the river.
Discharge (m^3/s)	River discharge refers to the total volume of water in the river. It is a function of the cross-sectional area of the stream, and the velocity. A wide, deep river or stream will have a greater discharge than a shallow, narrow stream, assuming their flow velocity is the same. Conversely, two rivers of similar size may have quite different

	discharges if the flow velocity differs. The discharge, together with pollutant concentrations, such as N, can be used to calculate the total pollutant load to the river.

For practical reasons (lack of equipment and insufficient time etc.) only 6 of the above-mentioned parameters were actually measured in the field. The measured parameters were DO, temperature, turbidity, pH, EC, SS plus physical characteristics such as velocity and depth/width.

All of these parameters were measured on the same day, to avoid the data getting influenced of different weather conditions. To be able to make all of the sampling sites in one day, the group split into two working teams, one working upstream sites and one working downstream sites.

Most of the parameters were measured out in the field using standard equipment. Each of the two sub-teams used equipment such as DO-meter and EC-meter, combined with thermometer. As only one turbidimeter was available, water samples from one sub-team were brought back to base-camp for this measurement. Also, only one flow-meter were available, so one sub-team used the method of letting an object flow ten metres downstream, time it, and then calculate the velocity.

EC, pH, temperature and DO was measured at left and right side of the stream and in the middle. The value used for later analyses was the average of these three measurements.

2.3 Biological Indicators

The importance of using biological indicators to assess the health of aquatic ecosystems, and in general the need to adopt an ecosystem health perspective in monitoring and managing rivers, is increasingly being recognized (Karr & Chu, 1999). Human induced changes to the catchment, flow and water quality will modify the resident aquatic biota. Aquatic pollution and habitat modification can therefore be investigated using biological indicators (i.e. studies of living organisms). Freshwater macro-invertebrates are mostly small fauna that inhabit the bottom of streams. They include mites, shrimps, crayfish, snails, mussels, worms and the multitude of insects and their larvae. Using the macro-invertebrate assemblages that characterize freshwater environments as biological indicators provides several advantages for studying river health:

- They are sensitive to the cumulative impacts of a wide range of disturbances
- They are differentially sensitive to various pollutants; the pollution responses of many common species are known; and they can detect and respond to intermittent pollution.
- They react fairly quickly and are capable of a graded response to a broad spectrum of stresses
- They are normally abundant and relatively easy to collect
- They generally move only small distances, and therefore their distribution may reflect the various impacts on river health over time at the sampling site
- They live long enough to provide a record of environmental quality
- Qualitatively sampling and analysis are relatively easy to carry out

(Sangpradub,1997; Jørgensen, 2001; Sand-Jensen & Lindegaard, 1996)

The collection of the macro-invertebrates was carried out at 12 selected sampling sites, whereof 10 were along the main river. They were sampled qualitatively, even though notes were made on dominant/abundant species at each site (see appendix 1).

Sampling was conducted following general methods such as recommended by Karr & Chu (1999) and Sand-Jensen & Lindegaard (1996). Both a surber sampler and homemade sieves were used for sampling. Only animals larger than 2 mm in length were collected in accordance with the recommendations of the used species identification key. Larger animals, such as crabs and shrimps were identified in the field and released; others were put in plastic bottles (preserved in formalin solution) and brought back to base-camp for later identification. At the base-camp animal samples were then hand-sorted on white trays using forceps. All specimens were identified to the lowest possible taxonomic level using the available keys and equipment.

The biological indicator key system (A Guide to Freshwater Invertebrates of Ponds & Streams in Thailand, Kanjanavanit & Tilling, n.y.) that was applied is developed for use in

Northern Thailand river systems. It is a qualitatively method, based on a more complex British biological indicator key method*, but simplified so that local people can apply it themselves. It consists of a total of 35 indicator- "species", within a total of 4 main groups: molluscs, crustaceans, insects and worms. In the key the groups are arranged in order of pollution tolerance, from those that can only live in the cleanest water to those that can put up with very dirty water. Each animal found, gives a certain score (1 to 10) and for each sampling site these scores are added and then divided by total number to find an average score. This average score makes up the "water-quality index score", which lies in the range of 0-10. 0 is given for very bad water-quality and 10 are given for very good water-quality (see appendix 2 and graph 6 in section 3.1). It is important to calculate an average score, as this will reduce any error made from sampling. The highest scoring animals are those most sensitive to pollution (that is pollution that reduces oxygen levels, and in other ways deteriorate the habitat of the animals). The lowest scoring animals are those that thrive in polluted circumstances (that can tolerate longer periods of low oxygen), such as midge larvae and segmented worms. Many animals fall in between. It is important to note that these scores don't measure pollution from some chemicals such as mercury or pesticides. These are poisons that can directly harm or kill animals directly.

2.4 Soil Sampling

Soil samples were done at some of the selected sampling sites along the Khun Samun and along few of the side rivers. Of practical reasons the soil samples were taken at the same sampling sites as biological indicators species were collected. Soil samples were done to estimate soil erosion on the riverbanks and from riverbank into the river. It was also done to get an overview of the soil fertility in the soils close to the river.

The sampling plots were created with the GPS measure for the sampling site in the middle and then by measuring five metres downstream and five metres upstream. Then five metres inland, so that two plots (one on each side) of 5 x 10 metres were created. The GPS measure was used so that vegetation cover or steepness of slope did not influence the selection of

* T*he key is adapted by Oy Kanjanavanit & Stephen Tilling, from the original key to British freshwater animals by Richard Orton, John & Anne Bebbington.*

plots, as steepness, vegetation cover and in general accessibility to the river would have an influence on the soil. As sampling sites were chosen from how it would be logical to measure water parameters (before and after junction and villages), the soil type or general traits in geology have not been taken into consideration when choosing the soil sampling plots.

A systematic rectangular grid sampling of the surface soil (top 20 cm) at both sides of the river at each sampling plot was done. The sampling plots where divided into six equally sized rectangles and the six sub-samples were taken with soil hand auger from the centre of these rectangles (see figure 2). The sub-samples were then mixed, and two soil samples (one from each side) of approximately 2-3 kg were brought home for analysis.

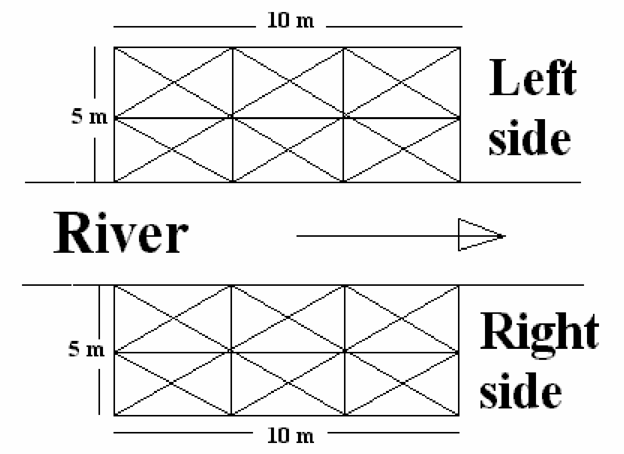


Figure 2: Drawing showing the placement of the soil sampling plots. Arrow indicates flow direction.

From each of the plots, the humus layer, depth of topsoil and topsoil colour were observed, and results from finger test on texture were noted. Slope of the plots were measured and general characteristics like plant coverage and present plant types or irregularities of the plot and immediate surroundings were observed.

Soil samples were tested for pH, content of N, P and K, and in six of the samples textual characteristics were analysed by separating and weighing the sand, silt and clay fractions.

2.5 Sediment and Plant Sampling

Sediment samples from the riverbed were taken from 10 of the same sampling sites as the soil samples. The composition of the particle size in the sediment and the difference in upstream/downstream composition can indicate whether an erosion of particles in the river takes place, as small particles need less energy from the water to be transported than do large particles. Small particles are transported a longer distance in the same time than are large particles (Morgan, 1995). Furthermore the shape of the particles together with the knowledge of what parent material they are made from can tell for how long the particles have been in the water. In fast running water the sediment samples will contain smaller particle size due to the sedimentation of small particles, while the particle size will be larger if the water is running fast. The sediment samples were taken to estimate the amount of erosion from upstream to downstream of the river.

Sediments where taken manually with a plastic bag on sampling sites where river was less than 1.2 metres deep, and with an Ekman sampler at sampling sites where river was deeper than 1.2 metres.
Sediments were taken from the riverbed in the middle of the river closest to the GPS measurement of the sampling site. It was collected in plastic bags for analysis.

Sediment samples were sorted into gravel, sand and silt + clay by sieving. Also various gravel sizes were sorted.

Plant parts of orange, cotton, maize, tamarine, linchee, passion fruit, pomelo, upland rice and some water plants from seven of the sampling sites where taken randomly for pesticide analysis. Plant parts were not taken systematically, but within walking distance from the actual sampling site. Plant parts were brought back for analysis. The plant parts were collected to assess the amount of pesticide used close to the different sampling sites. Doing this may indicate in what level, and on which crops pesticides are used, hence, giving an idea of the amount of pesticide residues in the plants still present. In this way an indicator of land use intensity at the various areas around the sampling sites would be available.

The plant parts were tested by adding the leaf sap into a standard solution, thereby getting a colometric assessment of the amount of pesticide present by comparing it to colour-sheets.

2.6 Secondary Data Gathering

When interviewing other groups standardized open-ended interview was applied. All interviewees are asked the same basic questions in the same order. Questions were worded in a completely open-ended format (Mikkelsen, 1995).

According to the limited time and the need of socio-economic data, we were conducting standardized open-ended interviews for gathering secondary data from other groups.

Representatives for questionnaires in each of the groups 1-5 were interviewed about their location to get an idea of the villagers perception of the overall uses of water and of the farming system and the villager's perception of the water quality in Khun Samun. Then inviting each location 1-5 to interview. Appendix 3 shows the questionnaires used for interviewing.

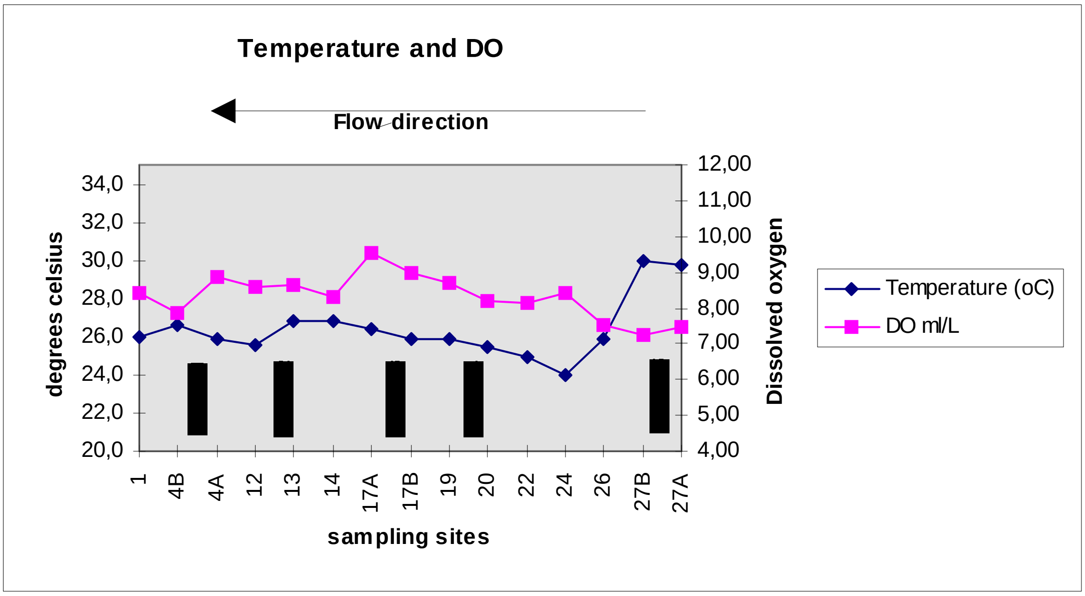
3. RESULTS

3.1 Water Sampling

Water Physio-chemistry:

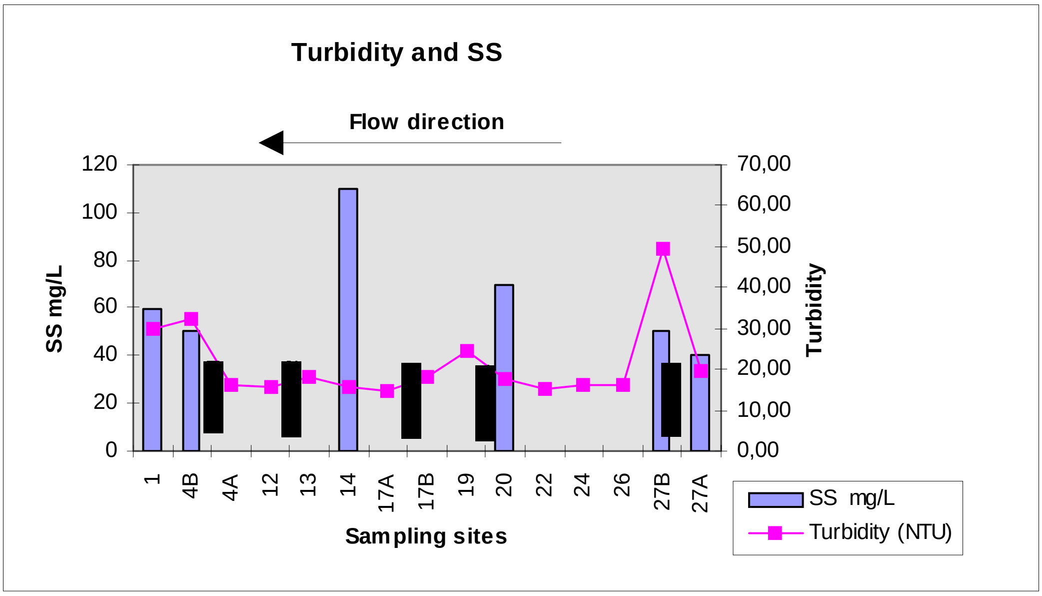
Relevant data were plotted into graphs together with the sampling sites. Only the sampling sites on the Khun Samun River were used, to get an idea of the development from upstream to downstream. The data were plotted in graphs, with the sampling sites on the x-axis and the different parameters on the Y-axis, to get a picture of the variations from upstream to downstream. Where relevant, two sets of parameters are put together in the same plot, to see if expected a relationships shows up.

Dissolved oxygen was found to be at generally quite high levels, at least at the Khun Samun River. Lowest level (3.70 ml/L) was measured at the side-stream of Huai Kaow, just before the junction with Khun Samun. There are no significant variations between the sampling sites on the Khun Samun River. The mean DO was 8.32 ml/L, the highest 9.56 ml/L and the lowest 7.23 ml/L. The water temperature ranged between 24.0 and 30.0°C, with a mean of 26.4°C and even though there were some variations, with a some what higher temperature measured upstream a direct relation between these two parameters are only vaguely implied by the graph:



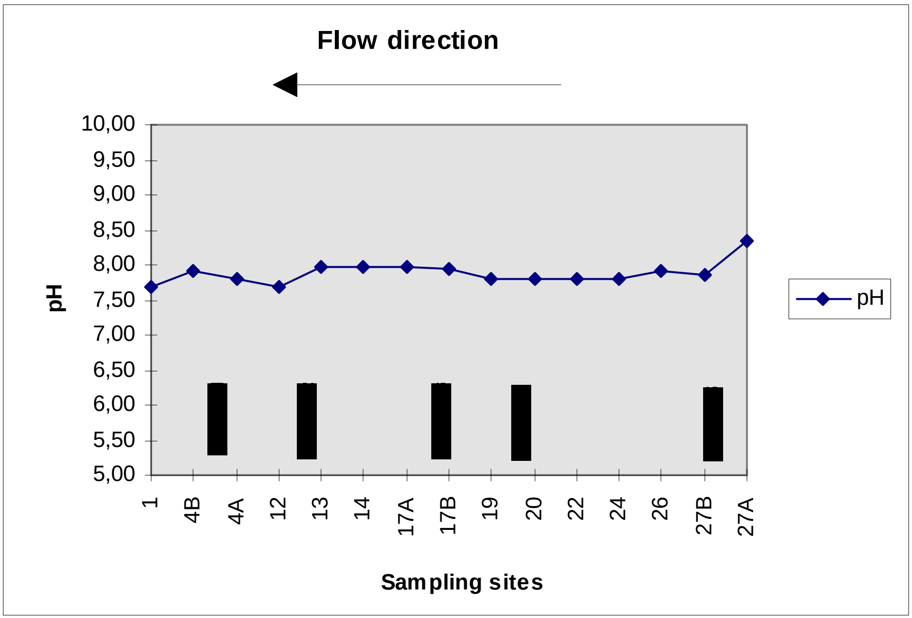
Graph 1: Temperature and Dissolved Oxygen from upstream to downstream

Turbidity lies between 49.5 NTU and 14.8 NTU, (with an average of 21.3), on a scale from 0 to 300 NTU, and with a significantly higher level at sampling site 27B - right after location 5. SS measures were not taken for all the sampling sites. The average SS is 63.3 mg/L and lies in the range 110 mg/L and 40 mg/L. There does not seem to be any relationship between the two parameters, when plotted into graph:



Graph 2: Turbidity and Suspended Solids Upstream-Downstream

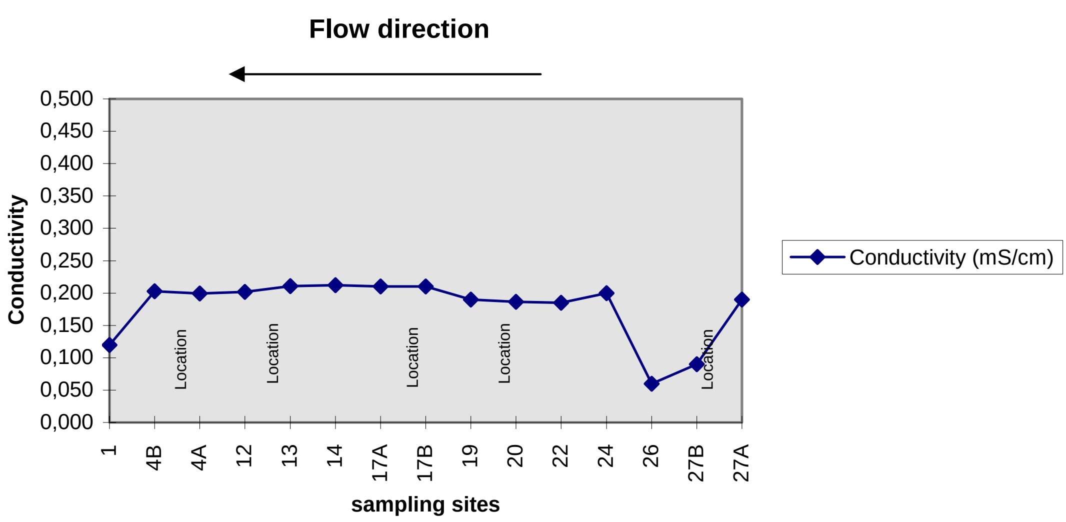
The pH levels was insignificant between sites, and ranged from 8.35 and 7.68, with a mean of 7.88:



Graph 3: pH from upstream to downstream

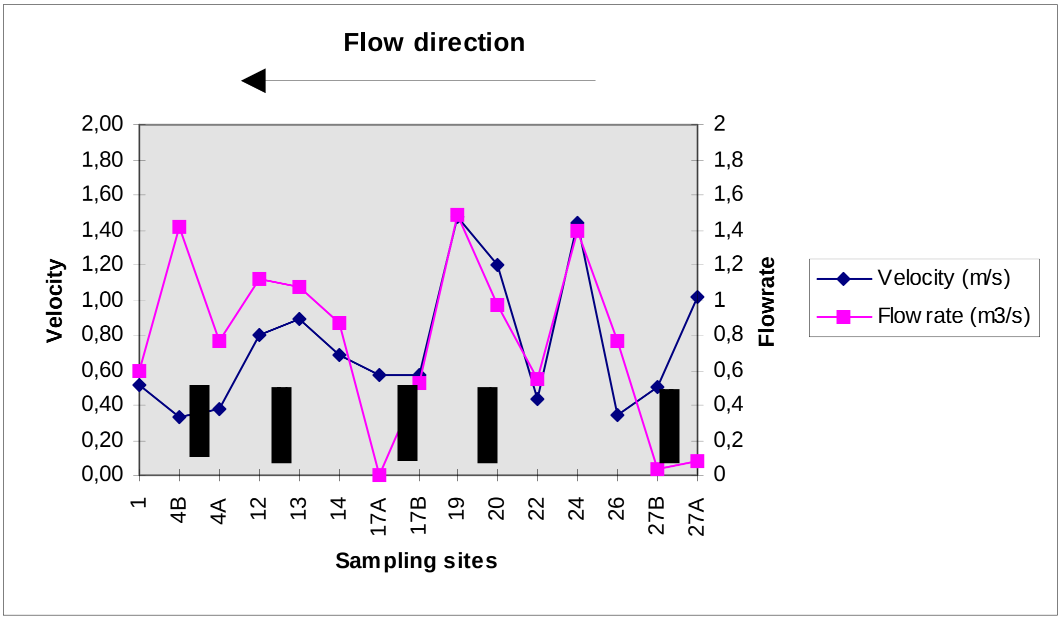
Conductivity also varied a bit down along the river, with the lowest values (0.06 mS/cm) around sampling site 27B and 26. The highest recorded value was 0.212 mS/cm and the mean 0.178 mS/cm.

The drop appearing after location 5 (sampling site 27B), is rather puzzling:



Graph 4: Conductivity from upstream to downstream

Water velocity ranged between 1.48 m/s and 0.33 m/s. The average flow rate was calculated (cross-section x velocity) to be 0.83 m^3/s (range: 0.04 – 1.49 m^3/s).

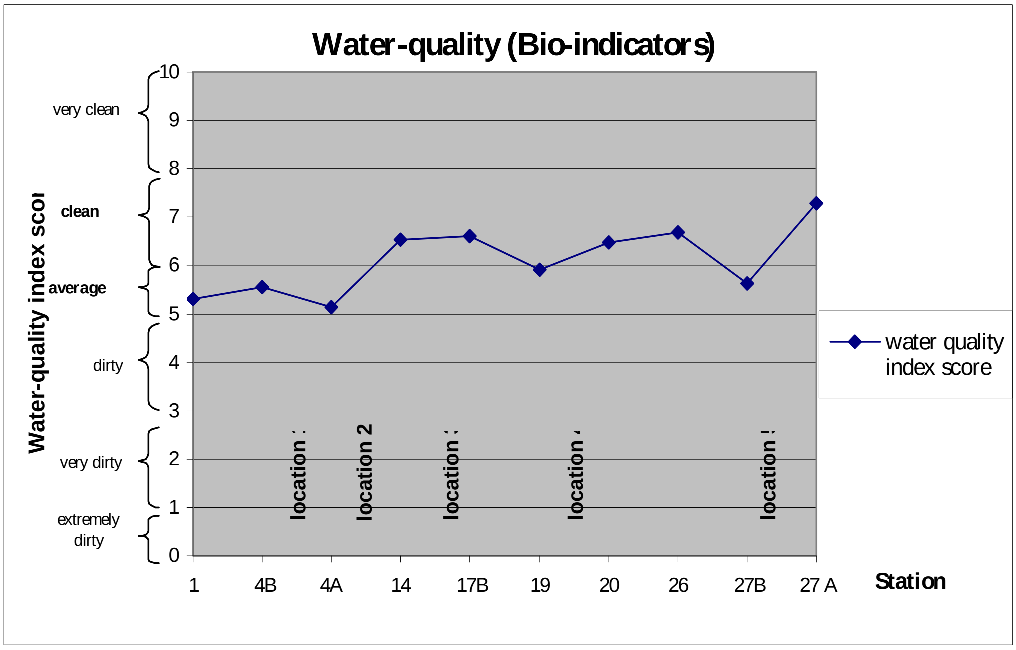


Graph 5: Velocity and flow rate Upstream-Downstream

For more detailed data from the sampling sites, see appendix 4.

<u>Macro-invertebrate Communities</u>:

All of the animals listed in the biological indicator key were found along the river, except for a few such as leeches and maggots (see appendix 2 for table of indicator species). This accounted for a total of about 10 different orders (only some of these could be determined to species or family levels). Other animals such as fish and frogs etc. was also found at a number of sites (see appendix 1 for site descriptions) but are not part of the indicator key and therefore not treated further. The calculated water-quality index scores were plotted in a graph together with the sampling sites, to get an overview of the development from upstream to downstream:



Graph 6: Water quality index scores (biological indicators)

3.2 Soil, Sediment, and Plant Sampling

All data from the soil samplings is collected in appendix 5.

In general the soils five metres inland from the riverbanks were found to be low fertile soils with none to very little humus and shallow topsoil. Colour was light brown to dark brown and slopes varied from 2° to 42°, with and average of 23° leaning towards the river. It was by sedimentation method found that soils were classified as sandy to sandy loam according to the USDA soil triangle (Borggaard, 2001). The rest of the samples done by finger test were to a large degree similar to the soil tested more thoroughly with a few exceptions. Content of N and K were low, where P content ranged from low to high. pH ranged from 6 to 7 showing a light acidious to neutral soil. Soils were often densely covered with trees, bushes and grasses.

From the data it can be seen that the soil within five metres from the riverbank are very low in nutrients and thereby not well suited for cultivation. Since most soils were estimated to be sandy loam, it is difficult to say anything about erosion when not having a reliable reference further inland. From observations in the field it is estimated that soils on the steep riverbanks generally had larger particle size than fields inland from the river. This could mean that at sampling plot with steep slopes leaning towards the river, induce a removal of small particles away from the sampled plot and into the river, i.e. a negative erosion in the plots. At sampled plots with a little or almost no slope the soil particles in the top 2-5 cm in general were smaller than soil particles at steep slopes. This may imply that non-steep sampling plots in the rainy season made up part of the riverbed, and when the water level drops, it leaves sediment on the riverbank. This cannot be seen from the results, since this soil is mixed with soil to a depth of 20 cm, which in this case often were of gravel size.

Due to time limitations and limited pre-knowledge of geographical Information Systems (GIS) soil results were not related to existing GIS maps of soil types in the whole watershed.

Data from samples of river sediment did not give results from which it is possible to draw any larger relations between the sampling sites. If we relate particle size to the flow rate of the river at the sampling site there are no clear relationship. Analysis of the shape of the particles was not conducted nor was estimation of the parent material. Data from sediment analysis is to be found in appendix 6.

From the collected plant parts the results may show a slightly increased use of pesticides around Ban Wang Tao compared to the other locations (see appendix 7). The samplings were few and it may look like type of the crop tested had a bigger influence than at what location the sample was from. Cotton and orange are both crops that traditionally require chemical uses (Rehm & Espig, 1991), and in these cases pesticide was detected. Only around sampling sites close to location 5 and the village in between location 4 and 5, Ban Huai Ra Phi, passion fruit and cotton were tested positive for pesticide residues. No pesticide residues were found around sampling sites close to location 2, 3, and 4. Refer to appendix 7 for data on plant pesticide residues. An important note will be that crops used mainly as basic household consumption crops all were tested negative in the pesticide residue test, i.e. maize and upland rice. Plant pesticide residues could not be detected in the few water-plants, since they contain a large amount of water that dissolved the pesticide to such a degree that our equipment was not sufficient to measure the small magnitudes.

3.3 Secondary Data

By interviewing other groups it can be seen that all 5 locations use water from Khun Samun for agriculture. From Huai Hua and Khun Samun only location 5 use water for drinking in dry season.

Villagers use mountain pipelines for households a lot more than water from Khun Samun. Villagers believe that river is polluted, but sometimes use it in order to survive. Only very little fishing in Khun Samun, they are raising fish in ponds instead. Villagers increase production of fish instead of over fishing. Concerning the dropping of waste and pollution to the river, pig excretion and garbage dump from location 4 are seem to be more severe than from other locations. In general villagers complain about upstream villages. No wastewater treatment is done in any villages before dropping into river.

Related to farming system in general herbicides are being used throughout watershed. It seemed like money was the main constraint for use of fertilizers. People in location 4 (Mien) grow rice and maize for their own consumption. The collected answers from all groups to the questionnaire can be seen in Appendix 8.

4. DISCUSSION

The perception, background, culture, believe etc. of the individual group members had a large influence on the results. For example affiliation to different traditions of thinking, in the last instance had an impact on choice of sampling site selection methods. Working in the group often led to less independent thinking so common decision-making concerned to e.g. sampling site selection had to be done. Communication, language barriers, and little experiences on how to use GPS and GIS led to large time consumption in terms of sampling site selection, discussion and decision-making. See 4.4 “common discussion” for elaboration on group work problems.

4.1 Water Sampling

4.1.1 Discussion on Results

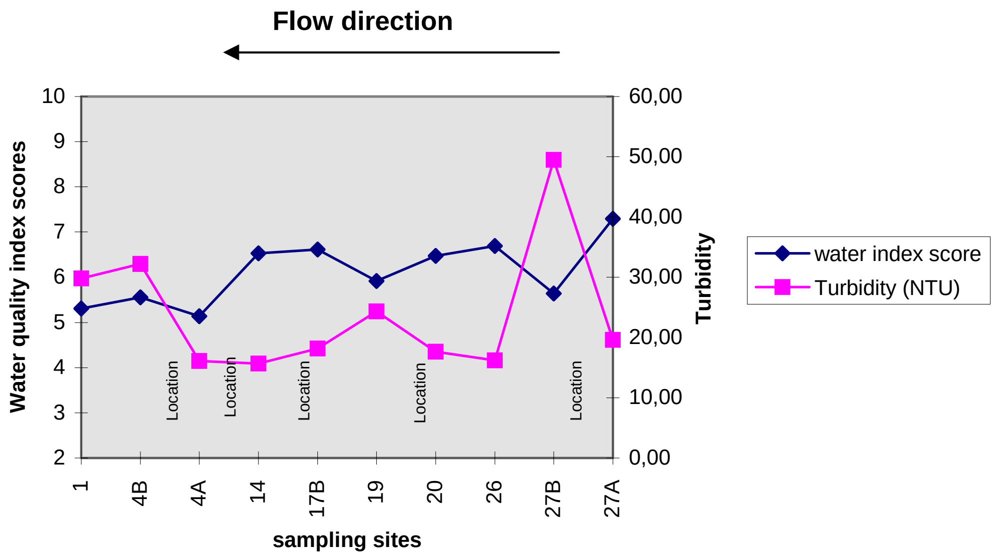
For methodological reasons most of the chemical and physical data that were measured will not form a basis on which conclusions can be drawn. It should, however, be mentioned that even though the variations between these parameters are not believed to form a basis for conclusions on variations from upstream to downstream, the average values of all the physical and chemical variables lies within standard ranges (Sangpradub *et al.*, 1997). Therefore there is no indication of any serious water-quality problems for the watershed as a whole with regards to physio-chemical characteristics. The parameters believed to be reliable are discussed in this section.

As shown by graph 1 in section 3.1 the turbidity rises significantly just after location 5 especially, and in general rises just after each of the villages. High turbidity levels indicate a degradation of the visual properties of the water, which can be caused by wash out of nutrients (from fertilizers or human waste-products), which causes eutrophication. The high levels after village number five could be due to their relatively high numbers of livestock (mainly pigs). Since this parameter rises immediately after each village, human settlement is believed to have a major impact on the water quality with respect to this parameter. The plot doesn't show any detectable correlation between SS and turbidity, as should be expected. This, to a certain extent undermines the credibility of the data, but since SS was not measured in as many sites as turbidity, and generally is more difficult to measure precisely, turbidity measures are still believed to be the most reliable.

The average pH levels were relatively high but the values still fall within acceptable range of natural waters (Sangpradub *et al.*, 1997). As with the rest of the parameters, the changes in pH doesn't show any pattern from upstream to downstream.

With regards to the biological indicators, the general pattern in the water quality index score was a slight decrease from upstream to downstream in the number and diversity of indicator animals found. Especially the reference sites furthest upstream had a high species diversity (with no "bad indicators" found). At the sampling sites furthest downstream it got more difficult to find the animals, both their numbers and diversity decreased, and "bad indicator" animals, such as segmented worms and midge larvae (that can survive with low oxygen levels) was appearing. The stone house caddis fly larvae, which are very sensitive to organic pollution, were only found halfway down the stream, (till site 14) which also goes for other pollution sensitive animals such as the prong-gilled mayfly nymph. However, some animals that normally indicate good water quality were found at almost all sampling sites, for example river shrimps and the flattened mayfly nymph (see appendix 2). This can be correlated with the general high oxygen levels, as these animals require a lot of oxygen to thrive.

The detected overall fall in water-quality index scores seems to be correlated with the changes in turbidity.



Graph 7: Relationship between biological indicators and turbidity

Where turbidity generally rises, the score in water-quality falls. This occurs immediately after the human settlements in the villages. Between villages turbidity generally falls again, while water-quality according to the index, rises. This could indicate the rivers capacity for self-cleaning in between the villages. When comparing sites upstream to those downstream an environmental impact there appears to be an overall environmental impact with regards to this parameter. However, it can be difficult to determine whether this impact is due to increased land use intensity, human settlement or disturbance in general or maybe just natural variation.

4.1.2 Method Critique

As already mentioned, some of the data obtained from the measurement of physio-chemical entities are believed to be rather unreliable due to a number of reasons. With regards to the physio-chemical data, the division of the group into two sub-teams caused some variation in the way different parameters such as DO, EC, pH and temperature was measured. Especially the velocity was measured with two completely different methods. By looking at graph 5, this seems evident when comparing the upstream sites to the downstream sites. On top of that comes the instrument uncertainty. The chemical and physical data should preferably have been collected with only one set of instruments, and also by the same person to eliminate this rather large uncertainty. Since this was not possible due to time constraints, the teams should at least have made sure that everybody used the exact same methods for each parameter measurement.

The only parameter that was measured with the same instrument and by the same person was the turbidity, which therefore is considered to be a reliable parameter. The same goes for the suspended solids.

As a final critique on the sampling of physical and chemical data, it should be mentioned that the picture drawn from these only is a “snapshot”. To get a more useful and realistic picture, sampling should have been conducted over a much longer period to get all seasonal variations. Furthermore, it would have been interesting to have had the possibility to measure parameters such as coliform bacteria, as the highest impacts on water-quality appears to immediately after each villages. This could indicate that human settlement is the factor that gives the highest impact on the river at the time of sampling.

As with the sampling of physical and chemical data, the biological indicator animals should have been collected over a much longer period to get seasonal variations covered. Biological indicators, however, still gives a more reliable picture of the overall situation, as these are less prone to immediate changes, for instance due to weather conditions. The animal composition doesn’t change from day to day, unless radical changes in the natural environment takes place. Another point of critique on the sampling method is that the biological indicators should have been collected more thoroughly (more time spend at each sampling site, and sampling more than one time). Also it could have been good to do quantitatively instead of just qualitatively sampling. Again the most important limiting factor was the time available.

For all of the water data, it would have been very illuminating if a baseline study of a similar river system had been available - preferably one with no or very little human activities, to see if the human settlement and the patterns of land use in Khun Samun watersheds in general has a significant impact. Also, the reference sites chosen in this study were not entirely free from human disturbance, as agricultural practises and other human activities were observed in these areas. The forests in the reference areas were secondary forest - not as would have been preferred primary forest. For this reason it is not possible to conclude whether conversion of natural, primary forest has significant impacts on river water-quality (or water quantity for that matter, had that also been an objective of the study).

4.2 Soil, Sediment, and Plant Sampling

4.2.1 Discussion on Results

Plots for soil sampling were selected as 5 x 10 m along the riverbank to estimate soil erosion from the riverbank. The results gave a general overview of the soil fertility status along the riverbank. To estimate erosion from further up field towards river as originally intended, new plots similar to the plots that were used, should have been sampled further up field (perpendicular to the river). This would have given numbers that could have been related to the present results.

Plots were on slopes of varying steepness. This may mean that flat plots are made up of riverbed in the wet season and steep plots are not part of the riverbed in the wet season, which may give a significant change in the nutrient content and particle size distribution of the soil. Small particles carrying nutrients may be washed out of the soil when water is covering the plot (Morgan, 1995).

When interpreting the soil quality from the status of low soil fertility on riverbanks it is important to know what purpose the soil is used for. If used for cultivation purposes low soil fertility normally means a need for external input or low yield. It indicates that surrounding fields may be similarly low in fertility hence a low soil quality. On the other hand, if fields further up from the sampling site are fertilised or naturally high in nutrients, it may mean that nutrient erosion from fields towards river is low – maybe reduced due to the buffer-vegetation along the riverbank.

When testing the particle size distribution in six of the samples a sedimentation process was used. This method revealed some reasons for mistakes and uncertainties, since the right laboratory equipment and conditions were not present. A homemade funnel was constructed to drain the clay and water from the tubes where sand and silt had sedimented. This may have affected the result, since the funnel took some of the silt up.

Many more conclusions could have been drawn if soil results had been related to GIS maps of the area. It could have been evaluated whether soil-sampling plots represented areas in the whole watershed, and conclusions for the entire watershed could have been drawn. As we now have the results these correlations can be made at a later stage.

The sediment sampling showed very varying results. The full objective behind taking the sediment samples is not clear nor is the reason for making the tests on sediment. This makes it difficult to interpret the results in connection to the overall objective of this study. Many of the factors in the problems of sediment sampling involved the interculturality and different ways of questioning the teachers. Hence further discussion of results on sediment samples will be in section 4.4 “common discussion”.

The few plant parts tested show that pesticides are mainly used in the cash crop for a larger yield, i.e. an increased income, whereas in the household crops no pesticide or very little is used. Moreover the cash crops cotton and orange, may act as an indicator for land use intensification.

4.2.2 Method Critique

Systematic grid sampling is the best strategy for minimizing bias and provides complete plot coverage. It furthermore ensures that the sub-samples will not be taken too close together. A limitation in this method is that it does not take into account the spatial variability of the plot (USACE, 1994). Choosing the systematic grid sampling also means that some samples according to the grid will be placed on inconvenient places, making it necessary to move the sub-sample a bit out of place and thereby "break the grid".

The size of the sampling plots was 50 m^2. According to Janesack (Pers. Comm., 2001) 6 sub-samples from 100 m^2 are sufficient and minimize the risk of choosing a small plot that does not represent the whole area. Having 6 sub-samples in 50 m^2 make a more precise, but more local sample (Janesack, pers. Comm., 2001).

The fact that sampling plots were placed as close to the GPS measure of the sampling site, contributed to increase the randomness of the sampling plot placement along the river. Sampling sites were selected to cater for the large-scale changes of the river network, i.e. before and after junction and before and after villages. Even though, when considering the physical conditions along the river, i.e. steepness of riverbank, vegetation cover, and other smaller factors concern, it seemed randomly placed. There were no large observable irregularities for the sampling plots compared to the surroundings. Few of the plots were *completely* inaccessible and moved to more convenient places, which could mean a slightly smaller humus layer and topsoil in our samples than it would have been in the inaccessible plot. In most cases where plots were showing dense vegetation cover and/or a very steep slope sampling was conducted anyway.

When selecting the sampling site, the fact that GPS measures mainly were taken where the road was close to or crossing the river has to be taken into consideration. This was done to make it possible to transport the equipment from the road to the river. It can be seen from maps that the road and the river is closest when mountainsides are creating a narrow path in the overall landscape. This could mean that chosen sampling sites along the river in general were closer to mountains than the river. In certain cases this may mean that sampling plots for soil sampling had a steeper slope than average, which could have an influence on particle sizes and nutrient content in the plots.

The sediment samples were taken in the middle of Khun Samun River. Sedimentation in rivers will occur in the whole width of the river and the samples should therefore have been supplemented with samples from left and right side.

The method in which the plant parts were collected is not a documented method, but plant parts are taken from fields that were passed on the way to the sampling site. As the samples were mainly taken to find out whether pesticides were used or not, and not in what quantity they were present, the sampling methodology must be regarded as less important.

4.3 Secondary Data

4.3.1 Discussion on Results

Concerning the collection of secondary data (socio-economic and farming system data) from the other groups 1-5. It would have been good to have pointed out one person from group 6 to follow the other groups work more closely from the very beginning of the fieldwork period. Also it has been difficult to get sufficient data from the other groups in time, as they have made their analyses and conclusion very late in the fieldwork period. It would be good if we had introduced and handed over the questionnaire to all groups in the beginning of the field course. Even though working under a time constraint, we made a good plan for interviewing the other groups and got qualified secondary data related to use of river and farming system.

4.3.2 Method Critique

The strong point of a standardized open-ended interview is that the respondents answer the same questions, thus there is comparability of responses; data are complete for each person on topics addressed in the interview. Reduces interviewer effects and bias several interviewers are used. This permits subsequent readers to see and review the instrumentation used. It facilitates organization and analysis of the data (Mikkelsen, 1995).

The weak points of a standardized open-ended interview, is that it has little flexibility in relating the interview to particular individuals and circumstances, standardized the wording of questions may constrain and limit naturalness and relevance of questions and answers (Mikkelsen, 1995).

In connection to secondary data collection interviewing other groups worked as intended. But it would have been better to inform to other groups and hand over questionnaires to them in the beginning of the field course. On the other hand the time limited each group, as they were busy with their own subject. Therefore some answers from them had short thinking. Working as the environmental group with mainly natural scientific background, we were lacking knowledge and experience on gathering socio-economic data in terms of questionnaires development and conducting the interviews. The results of secondary data collection could have been better if the group have had the knowledge and skills.

4.4 Common Discussion

Research like this, where a big overall objective like environmental condition is seeked to be assessed, it has for us been necessary to divide environmental condition into three issues; air-, soil-, and water quality. Doing that, limits us already in the starting phase since many would say that environmental condition covers more than evaluating these three phases. There are more natural scientific problem areas that can be argued for like vegetation quality, deep ground, atmosphere etc., but even more important social causes to and consequences of a certain environmental condition. These would be human impact, traditions, culture and a range of other factors.

Dividing the three main issues air-, soil-, and water quality further into measurable parameters limits us even more within making conclusions, since different people may weight factors within these three issues with different emphasis. Not only will the past, present and future physical uses of these three resources decide what factors are important, but also ranges of non-measurable factors like aroma, aesthetics, feelings etc. will have an impact. All things that differs with the perception of the viewer or user. When this is said it is important to note that a certain division of the term environment has to be done for then to assess each division to make conclusions for the whole environment. Coming to main conclusions from our results it must be said that related to the present use of the water resources in the Khun Samun river water quality must perceived to be rather good in comparison with places where lack of water resources is a bigger problem. As soon as the use of the river changes more to consumption and household, our grading of the water quality in Khun Samun will decline in relation to uses. In such case mitigation measures, e.g. sewage systems may be recommendable. In location five where villagers in times of water scarcity consume the water they will be exposed to a health hazard as the water quality will be low.

Results on soil quality do not show what was intended on erosion, but still gives us an overview of a low fertile soil. From our results and results from other groups and overall impression the soil quality in the whole watershed is rather low, at least according to the standards put for the equipment present, i.e. the soil testing kit. Merging this with all that is seen and heard from interviews with other groups, and our general impression of land use intensities in and around the five locations, land use is not the only main factor for environment impacts and limitations in Khun Samun watershed. It may also be people living in the watershed and their perception of themselves and each other and their relation to the resources in the watershed that determines the overall environmental condition.

Discussion on the group work and its benefits and disadvantages to our work

Use of days, under a time pressure, is an important matter, but by visiting and observing the five villages from upstream to downstream of Khun Samun watershed the first active day, was well spent and a good way to eliminate many problems during the following two weeks. Even though we were changing 2 sampling sites later, because of inaccessibility, selecting sampling sites directly from the map and thereafter mapping each sampling site in the field by using GPS was also one and a half days well spent for subsequently use of the following days efficiently.

Working in two groups during the water sampling added some problems in relation to use of equipment and uncertainties. Here it would have been appropriate to let the same people do the same measurements for all sampling sites, and divide according to what parameters was measured.

Being a group of students coming different universities, different backgrounds, and from different cultures working through interpretation may impose new problems and benefits in the work. The fact that this group worked with mainly natural scientific issues made in many ways the misunderstanding and misinterpretation of results smaller than the other groups, since much of our results were quantitative factors. Understanding each others' ways of working and the often very different habits to communicate actions to your counterparts have been our main problems along with the very different level of following and questioning authorities. The most clear example lies within the collection of sediment samples and plant samples, that only one in the group did and the rest of the group were not a big part of, and did not know the intentions nor the results of before very late in the process. Nevertheless we have been drawing some conclusions from the results, which may justify that the samples were taken. Problems like this could have been eliminated by opening the discussion in the whole group and responded to hints of intentions of the actors in the group discussions. A similar problem was when the group did the questionnaires. Only one student had the qualifications and was eager to create and conduct questionnaires, which resulted in that mainly this student were involved in the work. It again showed us that when all students in the group finally got involved with the questionnaires and its results, it was actually important information and good background information to obtain before drawing conclusions on our otherwise natural scientific results. Being from different backgrounds also imposed new exciting views and situations in almost any case, and the benefits of working together with someone who are used to climate, culture, living conditions, knows how to get around etc. always benefit a project.

Most of the language interpretation has been within the group as no Thai interviews with outsiders were conducted, and normally clarifying question could solve the misunderstandings. Most of the problems in our group have not been in the interpreting phase.

5. CONCLUSION

The objectives of this study was to study environmental impacts on the Khun Samun watershed with focus on the Khun Samun river and to investigate potential relationships between land use intensity and environmental condition.

The largest environmental impacts to the water in Khun Samun river seems to a large degree to be determined by the human settlement in the five villages, and to a lesser degree by the agricultural activities along the river. This can be seen from the study on biological indicators and some of the physical measures, as presented and discussed previously in this study. The major changes in these parameters occur immediately after the villages.

As the water from the Khun Samun River presently is mainly used for agriculture and other non-consumption purposes, the water may be stated to be of relatively good quality. It is, however, important to note that this conclusion is subject to change, should the usage of the water resource change. For instance, if the villagers were to start using the Khun Samun river water for drinking, then water-quality should be classified as poor with regards to this purpose.

From the data material collected, we cannot detect any significant influence from a potential increase in land use intensity down through the watershed, although there is a slight overall decrease in the biological water-quality index score. This change however is not so large and could just as well be due to natural variations along the river.

The soil on riverbank is in general estimated to be low in nutrient content. This may indicate that there is no or very little nutrient leaching from the surrounding fields to the river. This is seen as a good sign for the environmental condition, as nutrient leaching often is one of the major environmental issues in connection with rivers and nearby agricultural activities.

Based on the above-mentioned facts, the answer to our research question is, that no clear relationship between environmental condition, as defined in this study, and the land-use intensity in the watershed.

Overall we estimate that there are no present major environmental impacts that threaten to disturb the ecosystem in and around the river system. However, if population and land use intensity raises mitigation measures, such as the construction of sewage systems, must be taken in order to keep impacts under control.

ACKNOWLEDGEMENTS

The field work and first report writing has been done in the closest cooperation with our fellow Thai students, who should be the first to mention in this chapter. Big thanks go to Amornrat (Rat) Suntawiriyapan, Chokchai (Chok) Lerdkeittiwong, Rattana Buparsite and Supaborn (Noi) Lumwunnawong for their tolerance and patience. Secondly our two beautiful interpreters Pantipa (Poy) Suwansawang and Parinya (Prince) Bhanuwase should have our greatest acknowledgements as being irreplaceable in the many situations where communication and language barriers were obstacles in our work. In same line we owe our greatest thanks to our three ajarns connected to our work as supervisors and always being ready with answers to our questions, assist. Prof. Dr. Bongkotrat Pitiyont Bhanuwase, ajarn Dr. Orathai Mingtipol, and assist. prof. Dr. Veerasak Udumchoke. In connection to the fieldwork should also be mentioned all our co-students and the staff and assistants at the Nan Skill Development Centre.

At home in Denmark we owe our thanks to the whole SLUSE 2001 Thailand country group, with whom we have shared the good and hard times during the last 4 months. Further thanks go to the course responsibilities, supervisors and SLUSE Management Board, who are doing a good job in working intensely with both mind and heart to fulfil the objectives of the course.

REFERENCES

Borggaard, O. K. (2001): ”Soil Chemistry in a Pedological Context, 5th revised Edition”, KVL, Frederiksberg, Denmark. 426 pp.

Dudgeon, H. (1992): “Watersheds in Thailand” ?

Huang, G.H. and J. Xia (2001) “Barriers to sustainable water-quality management” in Journal of Environmental Management (2001) 61, 1-23.

Jørgensen, S. E. (2000): ”Principles of Pollution Abatement”, Elsevier Science Ltd, Oxford, UK.

Kanjanavanit, O. & Tilling, S. (n.y.): “A Guide to Freshwater Invertebrates of Ponds & Streams in Thailand”, Green World Foundation, UK.

Karr, J. R. & Chu, E. W. (1999): “Restoring Life in Running Waters, Better Biological Monitoring”, ISLAND PRESS, Washington D.C., USA.

Mikkelsen, B. (1995): “Methods for Development Work and Research – a Guide for Practitioners”, Sage Puplications Ltd, London, U.K.

Morgan, R. P. C. (1995): “Soil Erosion & Conservation”, second edition, Longman, England.

Rehm, S. & Espig, G. (1991): “The Cultivated Plants of the Tropics and Subtropics, Cultivation, Economic value, Utilization”, Verlag Josef Margraf, University of Göttingen, Germany. 552 pp.

Revenga *et al.* (1998): ”Watersheds of the World – ecological value and vulnerability”, World Watch Institute and World Resources Institute, Washington, D.C., U.S.A.

Sand-Jensen, E. & Lindegaard, C. (1996): "Økologi I søer og vandløb", G.E.C Gads Forlag, København, Danmark.

Sangpradub, N.; Inmuong, Y.; Hanjavanit, C. and Inmuong, U. (1997): "Effect of Headwater Catchment Degradation on Water Quality and Benthic Macroinvertebrate Community in Northeast Thailand", Nong Khai, Thailand.

Traynor, C.H.; Mingtipol, O.; Oksen, P.; Tancho, A.; Dontree, S.; Jongkroy, P.; Maneekul, R.; Ittihirunkul, P.; Wichawutipong, J.; Bonphitak, S.; Phaputnitisarn, S.; Kantangkul, P.; Waramit, N.; Siripoonwiwat, W.; Wattanapinyo, A.; Pengthemkeerati, P. and Waratanapong, P. (2001): "Basic Information for the SLUSE Field Course 2001, Khun Sumun Watershed, Nan Province", Maejo University, Kasetsart University, Chiangmai University, Royal Forestry Department, University of Copenhagen, Roskilde University Centre, the Royal Veterinary and Agricultural University, Copenhagen, Denmark.

UNEP, WHO, UNESCO, WMO (1992): "GEMS/WATER operational Guide, WHO Collaborating for Surface and Ground Water Quality; National Water Research Institute, Canada Centre for Inland Waters, Burlington, Ontario, Canada.