PARTICIPATORY RESEARCH ON UTILIZATION OF PULP AND PAPER EFFLUENT FOR AQUACULTURE AND AGRICULTURE

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ABSTRACT
This paper presents the research work that had been performed on the basis of participatory approach in order to cooperatively find out the feasibility of using pulp and paper effluent for aquaculture and agriculture. The effluent and/or seepage discharged from the land treatment area called as Project Green which is accounted for tertiary treatment. Such effluent is questionable to the communities in terms as impact to aquaculture, agriculture and water quality. Initially, the participatory approach was created by four parties consisting of community, academic institute (Khon kaen University), consulting company (Airsave Co Ltd), and industry (Phoenix and Pulp and Paper PCL). The villagers from the communities located nearby Pulp and Paper Mill were proposed on voluntary basis to co-work in three research tasks, fish pen aquaculture, economic crop production, and water quality. For fish pen aquaculture, 18 members had volunteered for this study. The villager’s role was for fish feeding, help measuring fish growth under the supervision of academic researcher, and observing as well as monitoring along the fish raising period of 4 months. Technically, three sites where are potentially influenced by the effluent and/or seepage including the seepage pond, the Chot lagoon where receives the effluent through the Chot stream from the Project Green and the Pong river near the outlet of the Chot lagoon were installed with six pens (3 pens with aerators and 3 pens without aerator) at each site. Each pen with the capacity of 30 cubic meters was filled with 800 fingerlings (Nile Tilapia). Fish growth in the Chot lagoon was higher than the seepage pond and the Pong river, respectively. Fish growth in the fish pen with or without aerator showed not significantly different. Averagely for the pen in the Chot lagoon, seepage pond and the Pong river were in the range 528-535 gmfish, 372-381 gmfish and 360-362 gmfish, respectively.

For the economic crop production focusing on rice cultivation, the cultivation plot were located along the effluent stream line, ie. The effluent discharged to the Chot stream and flow downward to the Chot lagoon. Therefore, 2 plots (Plot I and II) were located at the effluent upstream (Chot stream) and other 2 plots were located effluent downstream (Chot lagoon). Each cultivated site of 2 rai (approx. 0.8 acres) was divided into 4 plots consisting of plot without fertilizer (control), plot with organic fertilizer, plot with chemical fertilizer, plot with organic and chemical fertilizer. The average production yield at upstream location was a little lower than the downstream location, as indicated by 515 kg/rai, 537 kg/rai (Plot I and II upstream), and 541 kg/rai, 599 kg/rai (Plot III and Plot IV downstream). In comparison of rice production yield between the research plots and the adjacent rice field (did not participate in the research). The rice production yield was 385-721 kg/rai from the research plot compared to 365-471 kg/rai from the adjacent plots. The research plots yield was higher than the adjacent plots.

Based on the research findings, utilization of effluent of Pulp and Paper on aquaculture and agriculture was technically feasible. The technical findings, however, is hard to be comprehended and explained to most villagers in the communities if there is none of any villagers participated in this research. Mutual interest and understanding would lead to mutual respect and trust. That could create cooperation between industry and community on the academic knowledge of education institute. Problem could be cooperatively solved. Industry can use this approach for cooperative social responsibility.

Keyword: Participatory research, Utilization of Pulp and paper effluent, Aquaculture, Agriculture

INTRODUCTION
The Pong River is the major natural water resource of Thailand Northeastern Region. It is very important to all people who live by and associates with it. However, the problems of water pollution in the Pong River have become increasingly severe and more frequent since the past decades. The pollution incidences have generally occurred seasonally. Industries are blamed to be the main sources of pollution. The resulting water pollution affected not only to the Pong River but also the Chi and the Mun rivers further downstream. About ten years ago, the sugar mill on the river bank was accidentally spill molasses into the river, results in the poor capacity in receiving pollution of the water body. These incidences occurred despite many of the major industries close to the Pong River having implemented zero discharge policies. Other industries had also significantly decreased their organic pollution loading to the river. Although the industrial effluent is respected to the environmental regulations but it can be accumulated and caused long terms effect. The Pong river water pollution has had a significant impact on the scope of water uses of the river as well as on the aquatic ecosystem. Important affected water uses have included those for agriculture, industry, and domestic uses.

Along the Pong river, there are large industries situated on. One of them is Phoenix Pulp and Paper Mill (PPP), located in Nam Pong District, Khon Kaen Province. Its production capacity is 240,000-tons of pulp/year. Wastewater from the Mill process is directed to the biological treatment process of activated sludge system. Then the effluent from the treatment system is discharged onto the surrounding land for land treatment system, which has been implemented since May 1993 called as "Project Green". Effluent is used for eucalyptus plantation. Project Green covers the adjacent area of farmers who participate with the project (Figure 1).
Over the time of the project's operation, however, the nearby villagers have indicated many complaints. Excess effluent overflowed onto their cultivated area and also seepage through the soil and ground water causing damages to their paddy field, surface water and ground water sources. The investigation was performed and found that there is a great percentage of total dissolved solids in the Project Green effluent and possibly accumulated onto the soil of the Project Green.

Owing to the problems stated above, PPP needs to improve Project Green to operate without causing environmental impact, particularly to the nearby paddy field and cultivation area of the villagers. Accordingly, the Environmental Management Center (EMC), Faculty of Engineering, Khon Kaen University had performed the study on a detail design for improvement of treatment system of PPP. (Khon Kaen University; 2002) However, there is the limited land area for accommodation of the effluent loading. The impact of effluent which is mainly as seepage from the Project Green is still questionable. In addition, there is a crowded fish pen aquaculture located in the Pong River. Whenever, there are fish dead occurrence or any water pollution, ones suspect that it might be caused by the effluent of PPP through Project Green.

It is therefore necessary to find out whether impact of such effluent. The study was focused on impact of the effluent on fishery (fish pen aquaculture) and agriculture and water quality in the receiving water body. In other word, the study of such impact would be relevantly implied as the feasibility study of the effluent utilization. As mentioned above, the villagers who live nearby PPP have always wondered about the effluent impact. Accordingly, it is a meaningful approach to have the villagers participated in the research. Participatory research had been conducted for the comprehensive cycle since research designing, performing, result reporting, and presenting. Herein, it presents the overall picture of participatory research and present the study result of fish pen aquaculture as well as the agriculture of rice cultivation.

In order to cope with the environmental impact of the Project Green effluent, this study is aimed is to assess the feasibility of using the effluent for fishery and agriculture focusing on community participation. The study approach is based on mutual interest, understanding and respect. It would substantially create knowledge and confidence on effluent use, provide alternative of maximum use of water resource. If this study is feasible, it could be the pilot project for further application.

**RESEARCH APPROACH**

The participatory research recognized as the community research had been conducted by the cooperation of Khon Kaen University, Airsave Company and the communities located nearby the industry with the funding support from the industry as stated in the diagram (Figure 2).

Research approach is consisted of participatory and technical approach. Firstly, the academic researchers from Khon Kaen University, company and industry had discussion for the research plan. Secondly, the meeting with villagers from the communities nearby the Project Green area was arranged to find out the villagers volunteered to participate in 3 study groups, fish pen aquaculture, economic crop production, and water quality. Thirdly, technical approach was introduced by the academic researchers and co-carried out by the academic and villager researchers. Each research task using both participatory and technical approaches is subsequently described as follows.
1. Meeting of working group: Academia, Consultant and Industry for work plan.
2. Meeting with villagers for research project explanation and discussing with the villagers as well as seeking for villagers volunteering to participate in the research project.

3. Discussion of three individual study groups, fish pen aquaculture, agriculture and water quality.

**RESEARCH TASK 1: FISH PEN AQUACULTURE**

**Study approach:** On the participatory approach, there were 18 members volunteered to participate for fish pen aquaculture study. The members were then assigned to responsible for feeding fish food, measuring fish growth under supervision of the academic researchers, and observing or monitoring the study. Two members, one was the village head and one was villager, were selected to be the fish food feeder.

Technical approach on fish pen aquaculture, there were 3 sites for fishery location, seepage pond within Project Green area (called as Seepage pond), Chote lagoon (the effluent seeping to the Chot stream and flowing to the Chot lagoon), and in the Pong river (upstream of the Chot lagoon’s outlet). At each site, it was installed with 6 fish pens; 3 cages with aerators and 3 cages without aerators (Figure 3). Each cage was 30 cubic meters in capacity. Aerator was submersible pump with the pump rate of 2,000 liter per hour. Fish used in the study was *Nile Tilapia*. Approximately of 800 fingerlings (size of fingerling was 9.28 cm in length and 11.27 gm in weight) were raised in each fish cage. Fish food was ready made type containing protein of about 30%. Fish food feeding (by the assigned villager) was twice a day in morning and evening. Feeding had employed the practical way of villagers, ie. feeding food little by little and stop feeding soon as observing that the fish could not eat any more. Recording of fish growth (weight, length, width and thick of fish) was carried out every 15 days for 4 months (March-July, 2007). Twenty fishes of each cage were randomly sampled and measured. The assigned villagers were taught how to measure and record the data. The fish growth was averagely evaluated. Water quality (temperature, pH, DO, EC) were measured accordingly with the fish growth measurement. During the measurement, the members of this fishery group were the observers and monitors along the study period. The academia would share information and knowledge with the members all time. Presentation to other study groups and line agencies, local authorities, NGO, schools, were periodically conducted for information and knowledge exchange.
Figure 3 Location of fish pen aquaculture

Study result.

Technically, growth rate and survival rate of fish in the cages at 3 locations and with/without aerators for 4 months raising are described as follows.

Growth of fish in terms of weight and length. Fish could grow in all studied locations. However, fish pen aquaculture in the Chot lagoon were better than the ones in Seepage pond and Pong river; averagely for the pen with aerator as 535 gm/fish, 372 gm/fish and 360 gm/fish; and for the cage without aerator as 528 gm/fish, 381 gm/fish and 362 gm/fish, respectively (Figure 4). The length of fish show the same trend of weight pattern. However, they were not quite different as indicated in the range of 25.32 to 28.73 cm (Figure 4). Fish pen with aerator and without aerator did not present the effect on fish growth.

Figure 4 Fish growth measured as weight and length

Factors influencing the fish growth are dissolved oxygen (DO), pH, temperature (Temp) and total dissolved solids (TDS).
DO in the fish pen with and without aerator were similar and higher in the fish pens at the Chot lagoon, and lower in the Pong river and Seepage pond. DO content in the cage with aerator/without aerator measured at day time were 5.23/5.22 mg/L, 2.30/2.37 mg/L, and 1.53/1.47 mg/L, and during the night time were 4.15/4.14 mg/L, 2.43/2.52 mg/L and 1.74/1.81 mg/L, respectively (Figure 5). It is obvious that the higher DO content in the Chot lagoon than the Pong river and Seepage pond had influenced on fish growth. Topographically, the Chot lagoon is a large lagoon with much more surface area than other studied sites causes more aeration. In addition, there are more planktons and algae existed in the Chot lagoon that would enhance fish growth on the food chain basis. For the Pong river and Seepage pond, even though the DO content in the Seepage pond was lower than DO content in the Pong river the fish growth in both locations were not much different. Fish growth in the Seepage pond was a little higher. This result might be due to no crowded fish pens in the Seepage pond. In the Pong river it self there is a very dense fish pens existed.

![Figure 5 Dissolved Oxygen in the fish pen with and without aerator](a) Daytime  b) Nighttime)

For other factors, pH and temperature of three sites with/without aerators were in the range of 6.2-8.1 and 28.7 to 30.2 ºC, respectively. pH and temperature do not play role influencing on fish growth. Regarding TDS, the content of TDS were quite different at three studied sites as presented by 3.67, 1.38 and 0.16 millisemens /cm for the Seepage pond, Chot lagoon and the Pong river, respectively. Fish was able to grow in such TDS contents, implying that TDS did not influence on fish growth. It can be concluded that DO play an important role for fish growth.

Social aspect. Community involvement, in other word villager participation, is the key point of this study. Involvement or has been taken part since the beginning through the end of study process. Firstly, the villagers from the communities located adjacent to the Project Green area of Phoenix Pulp and Paper Mill were called for the meeting and the villagers had volunteered to the research study. They had shared ideas for fish pen aquaculture, for example fish feeding they like to do their own way to see the real impact on the existing performance. The scientific research might have to modify the research methodology to conform to the villager’s practical way, but still keeping the scientific analysis and synthesis. The villagers had been assigned for responsible of various tasks including fish food feeding, fish growth measurement, observing, monitoring, presentation. It is observed that the community involvement is significantly depended on the community leader. If the leader understand the concept and content particularly the mutual benefit (not in terms of money), he or she can convince the villagers to participate to do study.

RESEARCH TASK 2: ECONOMIC CROP PRODUCTION

Study approach. On the participatory approach, there were 4 farmers participated for rice cultivation (in-season rice field) and 7 farmers for corn cultivation (off-season rice field). Cultivation land is belonged to those participated farmers.

Technically, the location of cultivated land was selected along the effluent stream line, ie effluent upstream at Chot stream where receives the effluent seepage from Project Green, downstream effluent at Chot lagoon where effluent is diluted with a large amount of natural surface water in the lagoon as shown in Figure 6. This research task was studied during May to November 2007. Each cultivation land of 2 rai (approx. 0.8 acre) was divided in to 4 plots consisting of (1) control plot, (2) plot with organic fertilizer, (3) plot with chemical fertilizer, and (4) plot with organic and chemical fertilizer. The fertilizer used is up to the acquaintance of farmer which is 1 ton/rai of organic fertilizer, and 25 kg/rai of 16-16-8 formula chemical fertilizer. Kor-Khor rice species was used for cultivation. The following research activities had been carried out with the assistance of farmers, which were sampling of soil before and after cultivation, water quality measurement during cultivation, measurement of plant growth, production yield and component, and heavy metals in seed after harvesting.
Figure 6 Location of Rice Field Plot in Research Study Map

Before rice cultivation

Soil Sampling

Control Plot

Plot with organic fertilizer
Study result. The result presented herein is only for rice cultivation. Rice production yield cultivated in the rainy season, of which the whole picture is the high rainfall year, was likely high with the average of 500 kg/rai. Notably, it was noted that the production yield from 4 research plots of each cultivated rice field were higher than the adjacent rice field which was not participated in the research. However, the rice production yield from the research plots located upstream (Chot stream) was lower than the research plots downstream (Chot lagoon), as indicated by the average production yield of 515 kg/rai, 537 kg/rai (Plot I and II upstream, and 541 kg/rai, 599 kg/rai (Plot III and Plot IV downstream). In comparison of rice production yield between the research plots and the adjacent rice field (did not participate in the research), the research plots yield was higher than the adjacent plots. The rice production yield was 385-721 kg/rai from the research plot compared to 365-471 kg/rai from the adjacent plots. Rice production yield are presented in Table 1 and Figure 7.

Table 1 Rice Production Yield in Rainy Season (2007): kg/rai

<table>
<thead>
<tr>
<th>Rice Cultivation Method</th>
<th>Upstream Plot</th>
<th>Downstream Plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Adjacent rice field</td>
<td>375</td>
<td>365</td>
</tr>
<tr>
<td>Control (without fertilizer)</td>
<td>392</td>
<td>385</td>
</tr>
<tr>
<td>Organic fertilizer</td>
<td>663</td>
<td>495</td>
</tr>
<tr>
<td>Chemical fertilizer</td>
<td>503</td>
<td>753</td>
</tr>
<tr>
<td>Organic and chemical fertilizer</td>
<td>642</td>
<td>688</td>
</tr>
<tr>
<td>Average</td>
<td>515</td>
<td>537</td>
</tr>
<tr>
<td>CV (%)</td>
<td>16.18</td>
<td>12.14</td>
</tr>
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</table>

Rice Production Yield in Rainy Season (2007)

Figure 7 Comparison of Rice Production Yield

Regarding participatory study on the rice cultivation, the farmers are satisfied with the higher production yield and are seemly acceptable to use the water that is mixed with effluent. With the academic researcher who share information and knowledge how to cultivate properly and help solving problems if occurred, the farmers feel secured on cultivation with technical knowledge integrated with their own experience. They like to participate for further study. It should be noted that the industry had
supported the farmers for fertilizer and pumping water to the farmer plot. This support might be one of corporate social responsibility approach to the community.

CONCLUSIONS

This participatory research is actually aimed to have community involvement to study the impact of effluent (which is very questionable to the villagers) on fishery, agriculture and water quality of the receiving water body from the Project Green area of PPP. Fish pen aquaculture and production of economy crop study are presented herein. The conclusion can be summarized as for technical and social aspects outcome.

Technically, the fish could be raised by fish pen aquaculture at the effluent influencing zones; the Seepage pond, Chot lagoon and the Pong river. Fish growth in the Chot lagoon was better than the Seepage pond and the Pong river, respectively. Fish pen with or without aerator did not show the different in fish growth. DO in the important parameter affecting on fish growth. The study results indicated that utilization of effluent for fish pen aquaculture was feasible. However, the technically feasible study could not be understandable or the answer to the villagers who still have questions if they did not get involvement in the study.

Regarding the economic crop production, the rice cultivation is focused herein. It revealed that the rice cultivation using the water mixed with effluent, high mixing upstream at Chot stream and low mixing downstream at Chot lagoon, could make rice production yield somewhat higher than the adjacent rice field which did not participate with this study. The rice production yield of the plot located upstream was lower than the plot located downstream.

Social aspect in terms of community involvement/villager participation is a meaningful tool of this study. On the basis of participation, the villager participants can share their thought/idea, knowledge, information with the academia all time. The research could be accordingly modified to the practical way with keeping scientific method. The villagers know how to do research under coaching and supervision of the academia. While academia learn more local wisdom. The most important outcome is creation of mutual understanding and trust of all concerning parties (community, industry, educational institutes, line agencies), the villagers in particular. This is one of success cases for the participatory research. Currently, the expansion of participatory research has been currently going on, ie. fish pen aquaculture and air quality monitoring. This participatory research should be continuously performed and implemented to other factories. Participatory research will enhance the Cooperative Social Responsibility (CSR) of industry as well.

REFERENCES


