Peri-urban aquatic plant culture and skin disease in Phnom Penh, Cambodia

Vuong Tuan Anh, Wim van der Hoek, Annette Kjær Ersbøll, Chan Vicheth, Phung Dac Cam and Anders Dalsgaard

ABSTRACT

A cross-sectional study with follow-up was done in five communities involved in aquaculture in peri-urban Phnom Penh, Cambodia, to assess the association between skin disease, particularly dermatitis and occupational wastewater exposure. From 200 selected households 650 household members aged ≥ 15 years were visited and examined dermatologically three times in July 2004, January and May 2005. Overall dermatitis prevalence was 6.1%. However, all cases (116) were found in the two wastewater villages involved in aquatic plant culture. Risk factor analysis restricted to the two wastewater villages showed that involvement in wastewater-fed aquatic plant production increased the risk of dermatitis in the univariable analysis but not in the multivariable analysis. Among family members involved in wastewater-fed aquatic plant production a longer duration of daily wastewater contact did not increase the risk of dermatitis in the multivariable analysis. Wet season, older age and having a history of skin problems in the three months prior to each survey were associated significantly with dermatitis. Very few aquaculture workers applied personal protection and the factor had no significant effect on dermatitis. The present study did not show a consistent association between occupational exposure to wastewater and dermatitis, unlike similar Vietnamese studies.

Key words | dermatitis, exposure to wastewater, Phnom Penh, skin problems, wastewater-fed aquaculture

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INTRODUCTION

In many Southeast Asian cities and elsewhere, wastewater is widely used as a source of water and nutrients for irrigation in agriculture and aquaculture. Wastewater-fed food production systems bring benefits (income, employment and food) for poor households living in the peri-urban areas but are also important in securing a supply of cheap and nutritious foods for the urban populations (Leschen *et al.* 2005). However, there are many potential health risks associated with wastewater use. Direct occupational contact with domestic sewage can lead to infections by bacteria, protozoa and helminths. Consumers are also at risk when vegetables are contaminated with pathogens from the irrigation wastewater.

To protect public health and facilitate the rational use of wastewater and excreta in agriculture and aquaculture, the internationally authoritative WHO guidelines have been revised recently based on evidence from epidemiological studies and from risk assessments (WHO 2006*a*,*b*). There is substantial evidence that diarrhoea and intestinal nematode infections are associated with wastewater exposure whereas little research has been done on other potential health problems (WHO 2006*a*,*b*).

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A recent household survey in Phnom Penh, Cambodia, and Hanoi and Ho Chi Minh City, Vietnam, showed that skin disease was the most common self-reported health problem, perceived to be associated with wastewater contact during aquaculture work (Anh *et al.* 2007*a*). Studies in two Vietnamese cities, Hanoi and Nam Dinh, showed a strong association between dermatitis (eczema) and wastewater use in agriculture and aquaculture (Anh *et al.* 2007*b*; Trang *et al.* 2007*a*).

The present study was done to assess the association between occupational wastewater exposure and skin disease, particularly dermatitis in Phnom Penh, which had different agricultural and aquaculture practices from those employed in Hanoi and Nam Dinh.

MATERIALS AND METHODS

Study area

Phnom Penh has a population of nearly 1.3 million. As in other cities in Southeast Asia, untreated urban wastewater is discharged into peri-urban areas (e.g. natural wetlands) of the city. There are four areas in and around Phnom Penh where cultivation of fish and aquatic vegetables is a major activity. Figure 1 shows the location of five representative villages from these four areas. Detailed description of the selection of the five villages was reported previously (PAPUSSA 2003; Kuong *et al.* 2005).

Villages 1 and 3 (named Thnout Chrum and Kbal Tumnub, respectively) are located nearly 5 km from the Phnom Penh city centre around the Boeung Cheung Ek Lake (3,403 ha), which receives up to 80% of the city's domestic wastewater as well as industrial effluent from industrial zones located around the lake (Muong 2004). Farmers in both villages mainly cultivated edible aquatic vegetables such as water spinach (*Ipomoea aquatica*) and water mimosa (*Neptunia oleracea*) and sold their products to marketplaces in and around the city. Village 4 (Phum Mouy) is adjacent to the Boeng Kok Lake, a smaller lake close to the city that receives urban wastewater. Farmers of the village raise different types of fish such as snakehead (*Channa striata*), walking catfish (*Clarias batrachus*) and river catfish (*Pangasianodon hypophthalmus*) in net pen

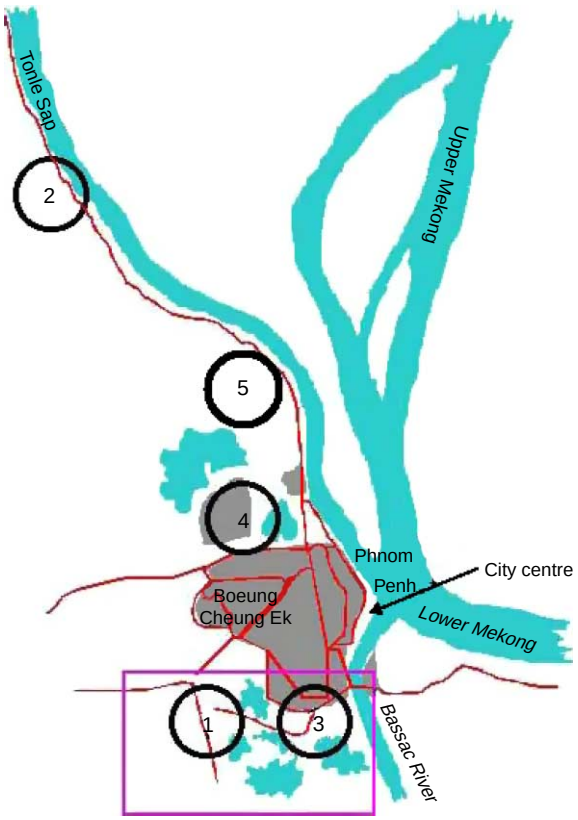

Figure 1 | Location of the five study villages in peri-urban Phnom Penh, Cambodia: 1) Thnout Chrum; 2) Phum Doung; 3) Kbal Tumnub; 4) Phum Mouy; 5) Chraing Chamresh.

enclosures often located under their houses built on the banks of the lake. Another peri-urban community, village 2 (Phum Doung) is situated about 10 km to the north of the city where the same fish species were raised in small ponds receiving water from a nearby non-wastewater lake named Prek Phnov. Finally, village 5 (Chraing Chamresh) is one of Phnom Penh's many villages located on the northern side of the city along Road Number 5, near the Prek Phnov Lake, about 9 km north of the city. The pond fish culture in this village depends on river water sources. Pangasius catfish is the main species grown in the village, although other species such as tilapia (*Oreochromis niloticus*) and silver carp (*Hypophthalmichthys molitrix*) are farmed in polyculture systems.

Study design and household selection

This study was designed as a cross-sectional study with two follow-ups. The first survey was implemented in

July–August 2004 in the middle of the rainy season. The second and the third surveys (follow-ups) were done during January–February and April–May in the dry season 2005, respectively. A total of 200 households were selected in the five villages distributed as 60, 28, 73, 14 and 25 households, proportional to the population sizes. More details on these 200 households have been reported by Anh *et al.* (2007*a*). Interviews were only conducted with household members aged ≥15 years old.

Questionnaire-based interviews and dermatological examination

Interviews were carried out by trained local assistants using a structured questionnaire, which is available at www.papussa.org. The questions were adapted from the Nordic Occupational Skin Questionnaire (NOSQ-2002), an international validated questionnaire for studies on occupational skin disease and exposure to environmental factors (Flyvholm *et al.* 2002; Susitaival *et al.* 2003). At the time of interviews, household members were asked if they had skin problems, with symptoms such as itching, dry skin and papules. If so, respondents were examined by dermatologists from the National Centre for HIV/AIDS-Dermatology & STD Control, Phnom Penh, Cambodia. Examination and treatment were given free of charge. In addition, household members were also asked whether they had any skin disorders during the three months prior to each survey. The dermatologists used a structured medical form to record symptoms of the skin disorder, and its localization on the body. In the study the focus was on dermatitis and in the questionnaire as well as in the medical form, dermatitis was defined as a superficial inflammation of the skin, which caused itching, with a red rash often accompanied by small blisters that weep and become crusted. Subsequent scaling, thickening or discoloration of the skin could occur.

Data management and statistical analysis

Data were entered in a Microsoft Access 2000 database and subsequently transferred to a statistical software program (SAS version 9.1) for analysis. Descriptive analysis of dermatitis in relation to the different variables was performed for pooled data from the three surveys for the five villages. Differences in prevalence of dermatitis were statistically tested with the Fisher-exact test. Further risk factor analysis was done only for the two wastewater villages adjacent to the wastewater-fed lake (Boeung Cheung Ek) because no dermatitis cases were found in the three other villages. Univariable and multivariable analyses were conducted for two subsets of data: 1) all family members aged ≥15 years old in these two wastewater villages; and 2) family members involved in wastewater-fed aquatic plant culture in the two wastewater villages. Initially, univariable logistic regression analyses were carried out to assess possible risk factors for dermatitis. Subsequently, multivariable logistic regression analyses were performed in order to evaluate the effect of the explanatory variables when adjusting for the effect of other risk factors. Explanatory variables were included in the initial multivariable models when their p-values were ≤0.25. A logistic analysis with repeated measurements (SAS PROC GENMOD) was used with generalized estimating equation (GEE). Backward elimination was used to include only explanatory variables with p-value <0.05 in the resulting models. The correlation between repeated observations from the same family member was modelled using an auto-correlation structure (compound symmetry).

Ethics

The study was approved by the ethics committees of the National Institute of Hygiene and Epidemiology in Hanoi, Vietnam, and the National Centre for HIV/AIDS-Dermatology & STD Control in Phnom Penh, Cambodia, prior to the study. Household members who participated in the study had given informed consent and were free to withdraw at any time during the study period. Any household member reporting a skin problem was given diagnosis and treatment for free.

RESULTS

Characteristics of the study population

During the first survey, 650 household members were interviewed; however because of the absence of some

respondents, the number fell to 632 in the second and 612 in the third surveys, yielding a total of 1,894 interviews. The mean age of the household members was 32.8 (ranging from 19.1 to 46.5) years and 49.4% of the respondents were female. The number of people aged ≥15 years old per household was rather consistent throughout the study population with an average of 3.4 ± 0.8. The number of household members engaged in aquatic food production was 237 in the 3 months prior to the first survey and 441 and 432 in the second and third surveys.

Household interviews

Nearly half of the household members who were involved in aquaculture reported that their hands, feet, legs and forearms were in contact with wastewater. Few household members (98/1,110, 8.8%) used personal protective measures during aquaculture work. These personal protective measures were mainly gloves (60/1,110, 5.4%), while shoes and boots were rarely used (<1%).

Across the three surveys, 660 episodes of skin problems were self-reported by household members within the three months recall periods. Itching was the most common (63%), followed by papules (44.4%), redness (17%), vesicles (7.6%), weeping and crusts (4.2%) and dry skin (2.9%). Main perceived causes of skin problems in the three months prior to each survey were contact with wastewater (52.3%) and contact with water in general (8.3%).

Dermatological examinations

Dermatitis was the most common skin problem diagnosed by the dermatologists (Table 1) with an overall prevalence of 6.1%. There was a reduction in prevalence of dermatitis from the first to the third survey. Dermatitis was only found in the two villages that were adjacent to the large wastewater-fed lake (Boeung Cheung Ek) with an overall prevalence of 9.1%. There were no cases of dermatitis in the two non-wastewater villages and in the wastewater village where fish net pen cultivation was practised. Of the 116 detected episodes of dermatitis, 16 individuals were positive for dermatitis in two surveys and one had dermatitis in all three surveys. Dermatitis was located on hands (71/116, 61%), followed by feet (54/116, 47%), legs (48/116, 41%), arms (31/116, 27%) and whole body (18/116, 16%).

Risk factors for dermatitis

The prevalence of dermatitis in relation to the characteristics of the study population in the five study villages is shown in Table 2. Results show that a number of explanatory variables were significantly associated with dermatitis, including contact with wastewater, average time of wastewater contact per day and use of personal protective measures.

Univariable analysis for all family members aged ≥15 years old in the two wastewater villages where aquatic plant cultivation was practised showed that wet season ($p < 0.001$), older age group ($p < 0.001$), history of skin problems ($p < 0.001$) and involvement in wastewater-fed aquatic plant production ($p < 0.001$) significantly increased the occurrence of dermatitis (data not shown). Five explanatory variables (season, sex, age group, history of skin problems and involvement in wastewater-fed aquatic plant production) were included in the multivariable model (Table 3). Three variables (wet season, older age group and

Table 1 | Prevalence of skin and nail problems (%) among household members in five peri-urban villages in Phnom Penh, Cambodia (2004–2005)

	Time of study			
Skin/nail problems	**July–Aug 2004 (n^* = 650)**	**Jan–Feb 2005 (n = 632)**	**April–May 2005 (n = 612)**	**Prevalence (N = 1,894)**
Dermatitis	58 (8.9%)	37 (5.9%)	21 (3.4%)	116 (6.1%)
Infectious skin disease	18 (2.8%)	14 (2.3%)	10 (1.7%)	42 (2.2%)
Urticaria (unknown causes)	6 (0.9%)	2 (0.3%)	5 (0.8%)	13 (0.7%)
Itching (unknown causes)	1 (0.2%)	1 (0.2%)	0	2 (0.1%)
Nail disorders (mainly fungal infections in toenails or fingernails)	6 (0.9%)	0	0	6 (0.3%)

*n: number of interviewed household members.

Table 2 | Characteristics of the study population and prevalence of dermatitis

Variables	N	Dermatitis	%	Fisher-exact test, p-value
N (n)	1,894	116	6.1	
Aquatic food production system				<0.001
Fish raising	413	0	0	
Vegetable culture	1,481	116	7.8	
Season				<0.001
Wet	650	58	8.9	
Dry	1,244	58	4.7	
Irrigation water source				<0.001
Non-wastewater (non-ww)	269	0	0	
Wastewater (ww)	1,625	116	7.1	
Village				<0.001
Village 1 (ww fed aquatic plant culture)	608	55	9.1	
Village 2 (non-ww fed fish culture)	269	0	0	
Village 3 (ww fed aquatic plant culture)	663	61	9.2	
Village 4 (ww fed fish culture)	145	0	0	
Village 5 (non-ww fed fish culture)	209	0	0	
Sex				>0.05
Male	959	50	5.2	
Female	935	66	7.1	
Age group (years)				<0.01
≤ 18	314	9	2.9	
19–28	577	27	4.7	
29–40	457	32	7	
> 40	546	48	8.8	
History of skin problems				<0.001
Yes	660	87	13.2	
No	1,234	29	2.4	
Contact with ww				<0.001
Yes	910	95	10.4	
No	984	21	2.1	
Duration of ww contact per day				<0.001
> 4 hours	688	79	11.5	
1–4 hours	222	16	7.2	
No ww contact	984	21	2.1	
Use of personal protective measures				<0.001
Yes	98	12	12.2	
No	1,012	84	8.3	
No involvement in aquaculture	784	20	2.6	

Table 3 | Risk factors for dermatitis in the two villages using wastewater for aquatic plant culture in Phnom Penh (all family members aged ≥15 years old)

				Multivariable analysis*		
Variable	**N**	**Dermatitis**	**%**	**Adjusted odds ratio**	**95% CI†**	**Overall p-value**
N (n)	1,271	116	9.1			
Season						<0.001
Wet	437	58	13.3	2.1	1.4–3.0	
Dry	834	58	7.0	1.0		
Sex						NS‡
Male	614	50	8.1			
Female	657	66	10.1			
Age group (years)						<0.001
≤ 18	233	9	3.9	0.2	0.1–0.5	
19–28	379	27	7.1	0.4	0.3–0.8	
29–40	320	32	10.0	0.6	0.3–0.97	
> 40	339	48	14.2	1.0		
History of skin problems						<0.001
Yes	639	87	13.6	3.2	2–5.1	
No	632	29	4.6	1.0		
Involvement in wastewater-fed aquatic plant production						NS
Yes	850	96	11.3			
No	421	20	4.8			

*Estimated variation between farmers in the resulting model was 0.018.
†95% confidence interval.
‡not significant in the resulting multivariable model.

history of skin problems) remained significant in the resulting model. However, involvement in wastewater-fed aquatic plant production in the two wastewater villages was not significantly associated with dermatitis in the resulting model.

In the analysis restricted to household members involved in wastewater-fed aquatic plant production, wet season ($p < 0.001$), older age group ($p < 0.002$) and a history of skin problems ($p < 0.001$) were associated with the occurrence of dermatitis. Contact with wastewater ($p < 0.1$), longer duration of wastewater contact ($p = 0.15$), and use of personal protective measures during working ($p = 0.47$) were not associated with dermatitis (data not shown). Table 4 shows the multivariable analysis of six explanatory variables for dermatitis among household members involved in wastewater-fed aquatic plant production in the two wastewater villages. Only wet season, older age group and history of skin problems were found to be significant in the resulting model while contact with wastewater during working and duration of daily wastewater contact were not.

DISCUSSION

There was a striking difference in prevalence of dermatitis between two villages where wastewater-fed aquatic plant production was practised and three villages with other aquaculture practices (9.1% vs. 0%, p-value <0.001). This finding is consistent with two studies from Vietnam that had a comparable design (Anh *et al.* 2007*b*; Trang *et al.* 2007*a*). In all three studies, exposure to wastewater stands out as an important risk factor for dermatitis. However, within the two wastewater villages in the present study we did not find a significant difference between people heavily exposed to wastewater and those not involved in wastewater-fed aquatic plant production at all. Prevalence of dermatitis in the wastewater exposed sites was 9.1% in the Phnom Penh

Table 4 | Risk factors for dermatitis among family members aged ≥15 years in the two villages using wastewater for aquatic plant culture

				Multivariable analysis*		
Variable	**N**	**Dermatitis**	**%**	**Adjusted odds ratio**	**95% CI†**	**Overall p-value**
N (n)	850	96	11.3			
Contact with wastewater (ww)						NS‡
Yes	816	95	11.6			
No	34	1	2.9			
Duration of ww contact per day						NS
> 4 hours	659	79	12.0			
≤ 4 hours	157	16	10.2			
No ww contact	34	1	2.9			
Season						<0.05
Wet	227	40	17.6	1.6	1.03–2.5	
Dry	623	56	9.0	1.0		
Sex						NS
Male	413	39	9.4			
Female	437	57	13.0			
Age group (years)						<0.01
≤ 18	143	8	5.6	0.3	0.1–0.6	
19–28	254	23	9.1	0.5	0.3–0.8	
29–40	235	26	11.1	0.5	0.3–0.9	
> 40	218	39	17.9	1.0		
History of skin problems						<0.01
Yes	601	85	14.1	2.8	1.4–5.7	
No	249	11	4.4	1.0		

*Estimated variation between farmers in the resulting model was 0.05.
†95% confidence interval.
‡not significant in the resulting multivariable model.

study, which is lower than that in Hanoi (10.4%) and in Nam Dinh (21.4%) (Anh *et al.* 2007*b*; Trang *et al.* 2007*a*). No dermatitis cases were recorded in Phnom Penh among the non-wastewater exposed sites, while the prevalence in this group was 2.1% in Hanoi and 7.5% in Nam Dinh.

The WHO Guidelines recommend a number of measures to protect aquaculture workers and local communities from skin irritants. These measures are: limiting exposure to wastewater, wastewater and excreta treatment (especially to remove chemical contaminants), wearing protective clothing (high boots, gloves), and rinsing the skin thoroughly with clean water immediately after contact with wastewater (WHO 2006*a*). In the Vietnamese studies the level of use of protective clothing was much higher than in Phnom Penh but even there, no significant protective effect could be shown. However, in Hanoi it was observed that farmers used short textile gloves and different types of textile-based footwear that are inadequate to protect their skin from the wastewater; such materials would just absorb the wastewater and mainly protect the skin from physical damage (Anh *et al.* 2007*b*). The effect of washing the skin after work was not assessed in the present study but had a protective effect for skin ailments among agriculture and aquaculture workers exposed to wastewater in Hanoi, if clean water from wells was used (Trang *et al.* 2007*b*). In the absence of resources to implement wastewater treatment, personal protection remains an important option for minimizing occupational exposure to wastewater. However, in intervention studies and promotion activities, emphasis should be on measures that are acceptable and affordable to

the local communities. Observations in Vietnam showed that farmers found the use of gloves and boots cumbersome, limiting their farming activities (Knudsen *et al.* 2008). It is important for health promotion activities that people perceive skin disease to be related to wastewater exposure; however, they do not consider it a very serious health problem.

No cases of dermatitis were found in the village that cultivated fish in net pen enclosures under their houses. Although the houses were built on the bank of a small, urban, sewage-receiving lake, observations suggested that they were less exposed to wastewater during aquaculture production, compared with the two wastewater villages where aquatic plant production took place. We had to restrict the risk factor analysis to the two wastewater villages where dermatitis cases were found. Within these two villages, we found an unclear association between occupational exposure to wastewater and dermatitis among aquatic plant cultivators. Other unknown factors could have an effect on the association between wastewater exposure and dermatitis and confound the relationship: for example, exposure to pesticides during aquatic plant production. Pesticide use is a factor that needs to be included in future studies on wastewater exposure and dermatitis. No significant association between the duration of daily wastewater contact and dermatitis was found among people involved in aquatic plant cultivation. Similarly, studies from Hanoi were inconclusive in this aspect. One study found that duration of daily wastewater contact was not significantly related to the risk of dermatitis (Anh *et al.* 2007*b*). In contrast, in a peri-urban community that used wastewater for agriculture in Hanoi, contact with wastewater for more than 2 hours per day was significantly associated with skin ailments among agricultural workers (Trang *et al.* 2007*b*). The different studies suggest that a more accurate exposure assessment is needed, including frequency and duration as well as the intensity of wastewater contact. Methods could be adapted from the extensive literature on water exposure and risks for schistosomiasis. For example, in southern China, activity diaries adjusted for duration and the percentage of body surface area exposed were cost-effective and practical instruments for accurate quantification of human exposure to water (Ross *et al.* 1998).

We found a very low prevalence of fungal nail infections (0.3%) in the Phnom Penh study whereas in the Hanoi study, the prevalence (15.7%) was very high (Anh *et al.* 2007*b*). The different prevalence of fungal nail infections between the two studies could be explained by the older study population in Hanoi, who are more susceptible to the fungal agent and environmental factors (Levy 1997). In addition, unlike the present study, the Hanoi study was restricted to aquaculture workers.

The present study and the studies from Vietnam were not designed to relate dermatitis with specific agents in the wastewater to which farmers were exposed. Additional information from a study on environmental chemistry and concentration of heavy metals in wastewater and sediment conducted in the Boeung Cheung Ek Lake showed that concentrations of some heavy metals in sediment samples near the lake inlets were higher than the Vietnamese limit values (MSTE 2002). This was the case for zinc (Zn, maximum concentration: 857 mg/kg dried weight), copper (Cu, maximum concentration: 149 mg/kg dried weight) and lead (Pb, maximum concentration: 99 mg/kg dried weight). The concentrations were significantly higher than in the non-wastewater control site, suggesting a possible relationship between skin problems and toxic heavy metals in the present study. Furthermore, the lake sediment was strongly polluted with barium (Ba, maximum concentration: 688 mg/kg dried weight) (Marcussen 2007). A skin study from Hanoi, Vietnam also mentioned the possible aetiology of heavy metals in association with the occurrence of dermatitis (Anh *et al.* 2007*b*).

Drawing causal inference from a cross-sectional study is problematic as information on risk factors and health outcomes are collected at a specific point in time or during a short period of time. Wastewater exposure can occur before, after or during the onset of dermatitis. To overcome the limitation, we followed up household members on two more occasions to obtain repeated measurements (Ersbøll *et al.* 2004). In the present study, we did not distinguish between atopic dermatitis, which can be localized on the trunk or cover the entire body, associated with allergic diseases (for instance hay fever or asthma), and contact dermatitis. However, the clear difference in prevalence of dermatitis between the two wastewater villages practising aquatic vegetable production and the three other villages

with different aquaculture practices suggests that contact dermatitis was predominant among the 116 episodes of dermatitis. Also, we could not distinguish between 'irritant contact dermatitis' and 'allergic contact dermatitis', as patch testing was not available.

In conclusion, villages where wastewater-fed aquatic plant production was practised had a much higher prevalence of dermatitis than villages engaged in waste-water-fed fish production or non-wastewater-fed aquatic fish production. It is speculated that toxic heavy metals in wastewater and unknown biological agents could play an aetiological role. Despite inconsistencies in findings between several studies, personal protection methods still seem important for prevention of skin disease until the time that better aquaculture water quality can be attained.

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