Status of Antibiotic Residues in Shrimp and Prawn Muscle in Bangladesh and Associated Health Risk Assessment

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Introduction:

In Bangladesh, shrimp (*Penaeus monodon*) and prawn (*Macrobrachium rosenbergii*) farming is one of the most important sectors from the economical point of view and the position of this sector is second in terms of foreign currency earning. During the last three decades, this sector has drawn a special attention to the people due to its high export potential (ASCC 1995; Islam 2008; Ahmed et al. 2008). During 2010-11, Bangladesh exported 51,672 MT of prawn and shrimp, valued at US$ 470.16 million of which around 80% was shrimp by value (EPB 2011). Shrimp and prawn farming also plays a vital role in employment. Approximately 1.2 million people are directly involved in shrimp and prawn production activities and 4.8 million household members are also indirectly involved in this sector (USAID 2006). In the past, to maximise production various antibiotics and chemicals like nitrofuran, chloramphenicol, oxytetracycline, tetracycline, malachite green and crystal violet etc. were used prophylactically and therapeutically in shrimp and prawn farming to control microorganisms (Nowsad,2007; Shamsuzzaman and Biswas, 2012; Hossain et al., 2013).

Chloramphenicol (CAP) and nitrofurans are broad spectrum antibiotic that against gram-positive and gram-negative bacteria causes aplastic anaemia (M. Vass et al., 2008; Draisci et al., 1997). It has mentioned that chloramphenicol and nitrofurans prohibited in USA and Japan and explicitly banned in Canada and European Union countries for its carcinogenic characteristics. However, these are used in shrimp culture of Latin America and Asia where shrimps are grown for export to USA, EU and Japan to control the diseases (GEASAMP 1997). Until now it's not possible to assess the CAP carcinogenicity due to lack of scientific information though CAP is treated as carcinogenic by IARC (International Agency for Research on Cancer) in human (Hanekamp et al., 2003).

In recent years, many Southeast Asian Countries especially Bangladesh has been facing difficulties in meeting the present food safety standards of the importing countries specially Eu, USA and Japan. In 2008 and 2009, 18 and 44 consignments respectively were rejected by EU due to presence of nitrofuran and chloramphenicol (DoF 2014).These countries have imposed a lot of non-tariff embargos regarding food safety on the shrimp and prawn export of Bangladesh. Due to non-tariff rules, when banned antibiotics especially nitrofuran and CAP found in a sample all the shrimp and prawn of the farm from where the sample was taken caught and sold in the local market for the general people. It's a threat for health of the local people.

The objectives of the study are as follows:

- To find out the sources of the antibiotics that are available in the shrimp and prawn muscle of Bangladesh.
- To assess the health risks for the people of Bangladesh from antibiotics in shrimp and prawn muscle.

Materials and Methods:

Study sites

The present study was carried out in Satkhira, Khulna and Bagerhat districts, the south-western coast of Bangladesh. About 70% of country's shrimp and 80% of total prawn produced in these districts, which accounted for 70% of total shrimp and prawn export in 2009-2010 (DoF 2011).

Antibiotic residue measurement data

Data on the presence of antibiotics in shrimp and prawn muscle and feed were collected

from the Upazila (subdistrict) Fisheries Offices of Satkhira, Khulna and Bagerhat districts, DoF under the Ministry of Fisheries and Livestock, Bangladesh.

Questionnaire interview

Total 83 shrimp and prawn farms of which 49 contaminated and 34 non-contaminated, 5 feed factories and 09 hatcheries were interviewed. On the other hand, it was investigated 10 VMD shops to justify the name, composition and company name of chemicals that were mentioned by the farmers and hatchery and feed factories representatives. The interviews were conducted with pre-tested questionnaires developed for the study.

Sample collection

On the basis of information mentioned by the farmers during questionnaire survey, 08 PL (Post Larvae of shrimp/prawn), 02 shrimp/prawn shell and 02 unknown chemicals samples were collected at the time of survey and sent to the Institute of Food Science & Technology (IFST) Lab, Dhaka, Bangladesh for nitrofuran and chloramphenicol test.

Health risk assessment

The equation that used for calculation of EDI (Estimated Daily Intake) is as follows:

$$EDI = \frac{C \times Fi \times Ef \times Ed}{W \times Te} \quad (i)$$ (Bhatti et al., 2013)

Where,

EDI = Estimated Daily Intake (mg/kg/day)

C = Concentration of contaminant in shrimp/prawn muscle (mg/g)

Fi = Fish intake (gm/person/day)

Ef = Exposure frequency (days/year)

Ed = Exposure duration

W = Average body weight

Te = Average exposure time (Ed × 365 days)

Exposure duration is 70.7 years that is life expectancy of Bangladesh (UNDP 2014) whereas Fi × Ef = Fish intake (gm/person/year) = Total production – Total export/ Total population. In this case, total population-149.77million (Population Census, 2011), total shrimp and prawn production 57784.87MT and 45162.95MT respectively whereas total export 35677.78MT and 7059.71MT respectively (Fisheries Statistical Year Book, 2012 DoF, Bangladesh) were considered. It's noted that body weight data were collected from International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDRB 2012).

For estimating the carcinogenic risk, the equation that was used is as follows:

$$CR = EDI \times CSF \times ADAF \quad (ii)$$ (Bhatti et al., 2013; USEPA 2005)

Where,

CR = Cancer Risk

CSF = Cancer Slope Factor (mg/kg-day)$^{-1}$

ADAF = Age Dependent Adjustment Factor

In this calculation, 1.5E+00 that was considered as cancer slope factor of SEM noted in Integrated Risk Information System (IRIS) database (USEPA 2004) whereas 10 for 0 -< 2, 3 for 2 -< 16 and 1 for >16 years old were adopted as ADAF (USEPA 2005).

To assess the non-carcinogenic risk, the following equation was used:

$$HQ = \frac{EDI}{RfD} \quad (iii)$$ (Bhatti et al., 2013)

Where,

HQ = Hazard Quotient

RfD = Reference Dose

In this assessment, 7.0E-02 that was considered as reference dose of AHD noted in Integrated Risk Information System (IRIS) database (USEPA 2004). If HQ value is greater than one (01), it defines a non-carcinogenic toxic risk to human health.

Statistical analysis

Analysis of variance

The data were statistically analysed in MS Excel 2013. Single factor analysis of variance was used to compare the values of nitrofuran and chloramphenicol tested data.

Correlation

Karl Pearson correlation co-efficient equation was used to evaluate the inter-element relationship among depth (m), canal water, river water, ground water, neighbour Pond water, water Exchange, fertilizer, cowdung and contamination. The equation is as follows:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\{n\Sigma x^2 - (\Sigma x)^2\}\{n\Sigma y^2 - (\Sigma y)^2\}]}} \quad (iv)$$

Results and Discussion

Antibiotics in Shrimp/Prawn Muscle

Nitrofuran and chloramphenicol were found in 24 prawn samples (24%) out of 100 samples and in 11 shrimp samples (9.6%) out of 115 samples in 2011 (Fig: 01), 13 prawn samples (10.4%) out of 125 samples and in 7 shrimp samples (5.4%) out of 130 samples in 2012 (Fig: 02) and 24 prawn samples (21.1%) out of 114 samples and in 6 shrimp samples (5%) out of 132 samples in 2013 (Fig: 03). The average concentration of SEM, AMOZ and CAP was 2.44, 2.47 and 6.12µg/kg respectively in prawn where as that of SEM, AHD and CAP was 1.73, 0.42 and 1.27µg/kg respectively in shrimp (P< 0.05).

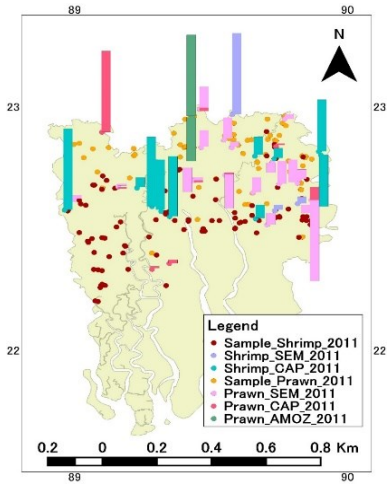

Fig: 01 Antibiotic detected shrimp and prawn ponds in 2011

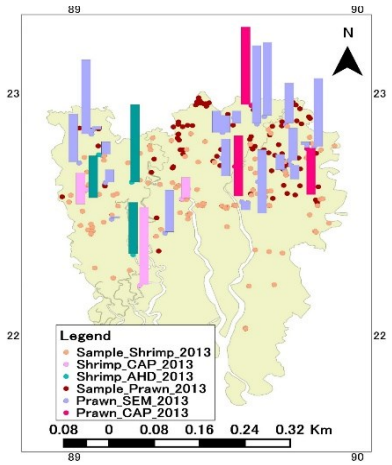

Fig: 02 Antibiotic detected shrimp and prawn ponds in 2012

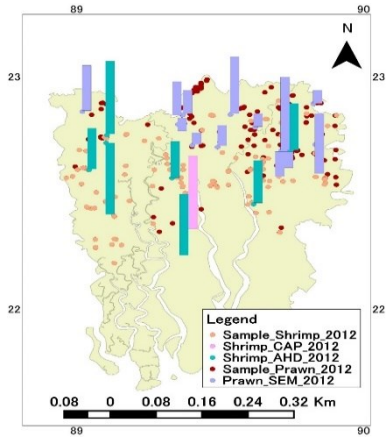

Fig: 03 Antibiotic detected shrimp and prawn ponds in 2013

Antibiotics in feed for shrimp and prawn

In 2013, AHD was found in 02 feed samples out of 30 samples that were collected from different feed factories. The average concentration of AHD in 02 contaminated samples is 18.65µg/kg (Fig: 04).

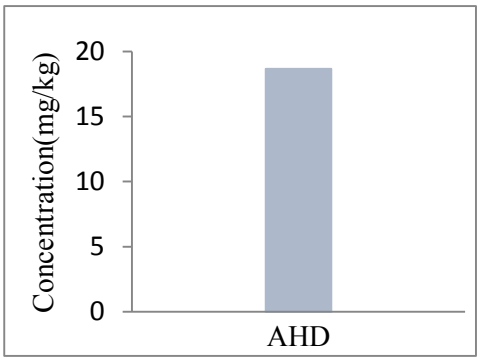

Fig: 04 AHD in feed for shrimp and prawn in 2013

The test result of collected shrimp and prawn PL, chemicals and shrimp and prawn shell samples presented in the following table:

01	Prawn PL	05	01	AOZ	0.60
03	Shrimp and prawn shell	02	01	SEM	0.80
05	Chemical-2	01	01	AOZ	36.00

So, it's clear that nitrofuran and chloramphenicol antibiotics are coming from hatchery, feed factories and use of contaminated shrimp/prawn shell as feed ingredient in shrimp/prawn.

The following table indicates that positive co-relation between water exchange and canal water and contamination and neighbour pond water respectively whereas negative co-relation was found between neighbour pond water and canal water, water exchange and neighbour pond water and contamination and water exchange respectively.

Parameters	Depth(m)	Canal water	River water	Ground Water	Neighbour Pond water	Water Exchange	Fertilizer	Cowdung
Depth(m)	1.00							
Canal water	0.03	1.00						
River water	0.05	-0.23	1.00					
Ground Water	0.38	-0.19	-0.09	1.00				
Neighbour Pond water	-0.26	-0.70	-0.33	-0.28	1.00			
Water Exchange	0.15	0.75	0.32	-0.13	-0.82	1.00		
Fertilizer	0.05	-0.14	-0.16	0.05	0.20	-0.24	1.00	
Cowdung	-0.19	-0.09	0.01	-0.16	0.16	-0.11	0.11	1.00
Contamination	-0.20	-0.42	-0.14	-0.05	0.50	-0.57	0.10	0.24

Carcinogenic Risk from SEM

The CR values of 0-<2, 2-<3, 3-<6, 6-<16, 16-<70.7 and cumulative 0-<70.7 age bins were 3.22E-06, 6.77E-07, 5.26E-07, 2.19E-07, 4.68E-08 and 4.69E-06 respectively whereas threshold level was 1.0E-06 (Fig: 05) for causing cancer (USEPA 2004). So, it`s clear that existing concentration of SEM in prawn is a threat as carcinogenic agent for the people of Bangladesh especially for the children.

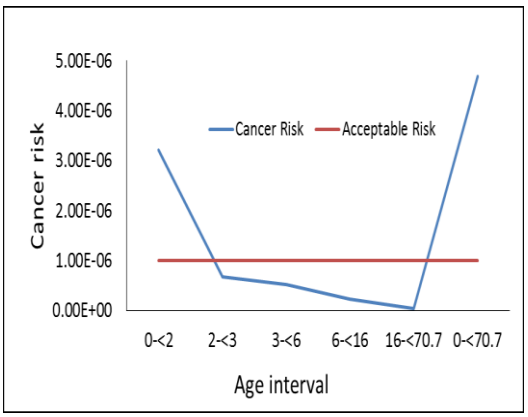

Fig: 05 Carcinogenic risk from SEM

Non-carcinogenic Risk from AHD

The Fig: 06 indicates that the existing concentration of AHD in shrimp has no significant effect on the people of Bangladesh.

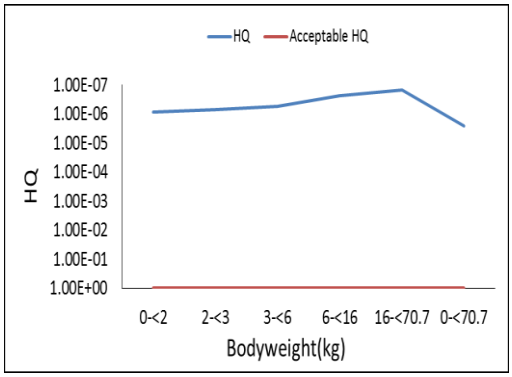

Fig: 06 Non-carcinogenic risk from AHD

Conclusions

The present study indicates that nitrofuran and chloramphenicol antibiotics are coming from hatchery, feed factories and use of contaminated shrimp/prawn shell as feed ingredient at farm level in shrimp and prawn. The lifetime carcinogenic risk (CR) of SEM was 4.69E-06 through consumption of prawn whereas threshold level was 1.0E-06. So, existing concentration of SEM in prawn is a threat as carcinogenic agent for the people of Bangladesh especially for the children. On the contrary, lifetime non-carcinogenic risk (HQ) of AHD was 2.56E-06 that was below the threshold level 1 through consumption of shrimp It means that existing concentration of AHD in shrimp has no adverse effect on the people of Bangladesh.

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