Discussion paper for topic 1

RUAF-IWMI e-mail conference on "Use of Untreated Urban Wastewater in Agriculture in Low Income Countries"

MOSQUITO-RELATED HEALTH RISKS OF WASTEWATER TREATMENT PONDS IN PER-URBAN AREAS OF FAISALABAD, PAKISTAN

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Wastewater use in agriculture has become a widespread practice in the world and now thousands of wastewater irrigation schemes exist (WHO, 2000). According to the UNEP, irrigation accounts for 69% of all global water use, while industry and domestic uses consume 23% and 8% respectively. After 30 years 50% more water will be required for domestic and industrial use (UNEP 1996). The problem is two fold: on one side, more water is required in cities due to expansion of both population and industry; on the other, there is pressure on the agriculture sector to meet the food needs of increasing populations. Therefore, the only solution to the problem is better utilization of limited water sources. The reuse of wastewater is one of the solutions to meet the growing demand of food production. In developing countries, including the breadbaskets of China and India, approximately 80% of urban wastewater is used for irrigation (Cooper, 1991). Unfortunately, much of this is untreated or inadequately treated. Wastewater contains high amounts of organic and inorganic matter, especially nitrates, phosphates, and other micronutrients. Thus it serves as a source of water and fertilizer, thereby reducing the need for artificial fertilizers. Urban wastewater consists of sewage and industrial wastes that pose biological and chemical health risks for the irrigators and communities in prolonged contact with the untreated wastewater, and for consumers of crops irrigated with wastewater. Thus, problems relating to health will arise if wastewater is used without any treatment, restriction and guidelines (Biswas, 1993).

For warm climate developing countries, wastewater treatment through sedimentation is considered as a first priority to reduce its negative impacts on human health. However, what has received little attention is the potential for these waste treatment ponds to serve as breeding sites for mosquito vectors of human diseases. Wastewater is rich in plant nutrients that promote the growth of vegetation which provides food as well as shelter against water currents and predators. Moreover, both vegetation and floating solid waste along the margin of ponds provides alighting places for mosquitoes to oviposit. Therefore, long term wastewater irrigation and treatment ponds where wastewater stays at least for 20 days may result in the creation of potential mosquito breeding sites. The situation is worse in developing countries where due to financial constraints, some treatment ponds are not in use but still contain stagnant wastewater. The creation of such perennial water bodies close to large urban areas may pose a significant health risk from vector breeding. In Nigeria, for instance, communities around wastewater treatment ponds have been found to suffer more frequently from mosquito nuisance and malaria than those that live far away (Agunwamba, 2001). Stagnant polluted water bodies also are a favoured breeding habitat of *Cx. quinquefasciatus and Cx. pipiens fatigans*, major vectors of bancroftian filariasis and certain arboviruses (WHO, 1989, 1995). Similarly in Florida, larval sampling from wastewater stabilization ponds indicated the importance of consideration of these factors when developing management plans for impoundment used for wastewater retention. These ponds led to the extremely high *Culex* mosquito population particularly *Cx. quinquefasciatus*, vector of filaria (Carlson DB, Knight RL 1987).

Pakistan is located in a severe water-scarce zone, which increases the scope of the reuse of wastewater and resultantly it is now being used for irrigation virtually without treatment and restriction in almost all cities. Treatment ponds have been constructed in some cities of Pakistan, but due to financial constraints most of them are in a non-functional condition (Aftab, 1999). These massive irrigation-related ecological changes occurring in Pakistan, stimulated us to conduct research on how these changes affect vector breeding and heath risks associated with them. This will then make it possible to plan appropriate management methods for disease vector control. The objective of this study was to investigate the health risks associated with mosquito breeding in a wastewater treatment and irrigation system at a site on the outskirts of Faisalabad, Pakistan. In addition present investigation will address the neglected issue of vectors' breeding in wastewater and will also highlight the importance of management of wastewater treatment ponds.

Haroonabad baseline study:

Mosquito breeding within the wastewater irrigation system around the town of Haroonabad in the southern Punjab, Pakistan was studied from July to September 2000 as part of a wider study of the costs and benefits of wastewater use in agriculture. The objective of this baseline study was to assess the vector-borne human disease risks associated with mosquito species utilizing wastewater for breeding. The results showed the presence of three medically important groups of mosquitoes *Anopheles, Culex* and *Aedes*. Four anopheline species, viz., *Anopheles stephensi* (84.3% of total anophelines), *An. subpictus* (11.8%), *An. culicifacies* (2.0%) and *An. pulcherrimus* (0.2%) were present, as were two species of *Culex*, viz., *Cx. quinquefasciatus* (66.5% of culicines) and *Cx. tritaeniorhynchus* (20.1%). *Aedes* were not identified to species level. The results of this study provided some interesting contrasts with previous findings indicating that *An. culicifacies, An. stephensi, An. subpictus and An. pulcherrimus* collectively preferred clear or turbid non-foul breeding water (Herrel *et al,* 2001; Reisen *et al,* 1981; Ansari and Nasir 1955; Ansari and Shah, 1950). Under the arid conditions of the study area, it was clear that foul water habitats were exploited by these species. However, only one species, *An. stephensi*, appeared to breed prolifically in these foul water habitats, with *An. subpictus* a distant second. The other two species occurred in trivial numbers and the wastewater system was quite obviously a relatively minor component of their overall breeding habitat palette.

Faisalabad Study (July 2001- July 2002):

A survey for immature stages seems to be best method for fauntastic studies of mosquito provided it is conducted regularly in all seasons covering all possible breeding sites. The main limitation of Haroonabad baseline study was, it was conducted only for three months (July-September 2000) which are the monsoon months and these are normally peak mosquito breeding ones. Based on these three months results it is very difficult to extrapolate our results to whole year and also very difficult to explain the significant occurrence of mosquitoes in wastewater. However, it provided the baseline data for more detailed full one year study in an area with different patterns of irrigation, like canal water, wastewater and mixed one to compare their breeding preferences and to check the consistency of breeding throughout the year and to produce the true picture of wastewater contribution in mosquito breeding.

Faisalabad is situated in Rechna Doab, located between the Chenab and Ravi rivers, 73.08'E, 31.25'N and at an altitude of 214m above mean sea level. The mean annual maximum and minimum temperature of the area are $48\pm2^{o}C$ and $10\pm 2^{o}C$ respectively and average annual precipitation is 550 mm. The total population of Faisalabad is 2 million. Ground water of Faisalabad is saline and drinking water is piped from Chenab well field 25 km away. There are 16 ponds in two rows each with 8 covering an area of 16 ha. Of these, six are aerobic and 6 are facultative while 4 are sludge dewatering ponds. The plant has been designed for an average flow of 90,000 m^3/d. This study is investigating the role of these wastewater treatment ponds in the generation of medically important mosquitoes. It is also looking the breeding preference of mosquitoes in surrounding area of treatment pond within a 2-Km. radius with different source of irrigation like wastewater (called Zone I), canal water (Zone II), mixed water (Zone III). The fortnightly mosquito larvae collection was planned from June 2001 to July 2002.

The occurrence and abundance of mosquito immature in different habitats reflect the ovipositor preference of females as well as the ability of the immature to survive in the conditions under which they find themselves. Changes in physio-chemical and biotic characteristics of habitats may create the conditions either favorable or unfavorable for their breeding success, depending upon the ranges of tolerance of different species (Amerasinghe *et al.*, 1995). This discussion paper based on results from July 2001 to February 2002, indicates 1,737 samples collection from treatment ponds. This results showed the collection of five *Culex* species viz., *Cx. quinquefasciatus* Say, *Cx. tritaeniorhynchus* Giles, *Cx. pipiens* Linnaeus *Cx. bitaeniorhynchus* Giles *Cx. pseudovishnui* Colless and six anophelines species viz., *Anopheles subpictus, An. stephesi, An. culicifacies, An. pulcherrimus, An. peditaeniatus* and *An. nigerrimus* were collected. Each mosquito group showed its association with particular pond. *Cx. tritaeniorhynchus* (West Nile fever, Japanese encephalitis), *Cx. quinquefasciatus* and *Cx. pipiens fatigans* (Bancroftian filariasis, West Nile fever) showed significant association with anaerobic treatment ponds. These ponds are characterised by turbid-foul water with low DO and EC. *Cx. bitaeniorhynchus* Giles and *Cx. pseudovishnui* Colless with facultative ones, which characterized by clear-foul water with high DO and EC. Generally, these species prefer foul and polluted water with low DO for breeding and these are pollution tolerant ones and other researchers document their existence in such habitats. For instance, Carlson and Knight (1987) have recorded extremely high *Cx. quinquefasciatus* populations in wastewater treatment ponds in Florida. In Pakistan, Reisen *et al* (1981) and Aslamkhan and Salman (1969) have reported that *Cx. tritaeniorhynchus* was a dominant species in polluted habitats in the summer; a similar phenomenon occurred with *Cx. pipiens fatigans* in the winter. Of *Anopheles* species, only *An. subpictus* showed association with these ponds, particularly with anaerobic ones while rest five species were collected from facultative ones. Such findings were well supported by Carlson *et al.*, (1986) who recorded the very high *Cx. quinquefasciatus* population in untreated wastewater and at later stage of wastewater treatment *Anopheles* species were dominant. Herrel *et al.*, (2001), Reisen *et al.*, (1981) confirmed its existence in foul and polluted water like septic tanks, street pools and street drains etc., for breeding and this species was able to tolerate a wide range of physio-chemical conditions including higher organic matter contents. *An. stephesi* (secondary malaria vector) and *An. culicifacies* (major vectors malaria) also showed breeding preference to treatment ponds but only to facultative ones though their total number, particularly *An. culicifacies* is low. Herrel *et al.*, (2001) and Reisen *et al.*, (1981) reported their significant existence in fresh and clear water in irrigated areas of Punjab. However, the results of Mukhtar *et al.*, (in prog.) also showed their existence in foul water. Krishnan, (1961) study also matched with ours as he found a positive correlation between *An. stephensi* existence and polluted water in winter when there is low rain and less irrigation practice in Punjab. *An. stephensi* has been considered important malaria vector throughout Asia, including Indo-Pak subcontinent and Persian gulf (Rao, 1984). Recent evidence from Sheikhupura, in northern Punjab suggests that *An. stephensi* may be a more important vector than previously believed (Rowland *et al.,* 2000). **NB: The results of surrounding areas (Zone I, II & III are at initial stage).**

Conclusions:

The prevalence of established vectors of human diseases such as *An. stephensi* & *An. culicifacies* (malaria), *Cx. tritaeniorhynchus* (West Nile fever, Japanese encephalitis), *Cx. pipiens fatigans* and *Cx. quinquefasciatus* (Bancroftian filariasis, West Nile fever) in the wastewater system indicated that such habitats could contribute to vector-borne disease risks for human communities that are dependent upon wastewater use for their livelihoods. Wastewater disposal and irrigation systems provide a perennial source of water for vector mosquitoes in semi-arid countries like Pakistan. Vector mosquitoes exploit these sites if alternative breeding sites with better biological, physical, and chemical conditions are not abundant. Therefore, proper understanding of breeding sites and preference of certain sites over other is vital to develop sound mosquito control strategies. This is particularly very important in areas where large scale irrigation is being practiced. No doubt, wastewater has been widely investigated from helminths and protozoan infection point of view, but neglected in case of vectors' breeding investigation. The results of Haroonabad baseline study have been further confirmed by more detailed investigation in Faisalabad that wastewater treatment systems can generate potential vectors of human diseases, and emphasizes the need for more research on this issue. This would then make it possible to develop appropriate environmental management methods for disease vector control. In this paper we have also highlighted the importance of proper management of treatment plants where prolong stay of wastewater results in creation of ideal habitats for mosquito breeding. Health planers and policy makers should consider vectors' breeding in the designing of wastewater reuse schemes. To the author's knowledge, there have been no previous published studies on mosquitoes breeding in wastewater-irrigated sites in Pakistan.

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