for pyrethroids during summer and winter seasons respectively. The risk assessment estimated that the 12.5-100% of sediments exceeded than the sediment quality guidelines while total DDTs level exceeded in 75-100% of sediments samples compared to the sediments quality standards. Indicative ratios of DDT with its isomer and metabolites suggested the past and current application and long transport range of organochlorine. Deltamethrin, cypermethrin and permethrin concentrations in water were found to be higher than their LC50 while levels of pyrethroids in sediments were below its LC50 values. Statistical analysis reflected the intensive agro-industrial activities and municipal effluents as major sources of organochlorine and pyrethroids in the freshwater ecosystem of river Chenab. The level of organochlorine monitored at Khanki Headworks (S3, S4) was relatively higher than the other three Headworks while level of pyrethroids was higher at Trimu Headworks (S7, S8) as compared to Marala, Khanki and Qadirabad Headworks. Organochlorine and pyrethroids levels in all the samples of water, sediments and fish were higher during winter season as compared to summer season. Organochlorine concentrations in fish ranged from 23.79 to 387.12 ngg^{-1} but 0.35 to 1.272 μgg^{-1} for pyrethroids during summer and winter seasons respectively indicated their bio-magnification in fish. Risk assessments of organochlorine pesticides showed that DDT contaminated fish intake would pose a health risk to humans. However, no immediate risk was assessed by pyrethroid contaminated fish consumption. Present study results highlighted both organochlorine (outdated) and pyrethroids (current) pesticides associated pollution in the riverine ecosystem of the river Chenab to mitigate the adverse situation. Current study also evaluated the phytoremediation potential of aquatic macrophytes (*Eichhornia crassipes*, *Pistia stratiotes*) and algae (*chaetomorphasutoria, sirogoniumsticticum* and *zygnema sp.*) for organochlorine and pyrethroids pesticides. Eleven treatments (T_1-T_{11}) with and without plants were used for phytoremediation of organochlorine and pyrethroid pesticides. Water and plant samples were extracted by liquid phase and solid phase extraction respectively and analyzed by high-performance liquid chromatography. During the experiment, *P. stratiotes*, *E. crassipes* and algae (*C. sutoria*, *S. sticticum* and *Zygnema sp.*) showed good removal efficiency with 62% (71% root, 29% shoot), 60% (67% root, 33% shoot), and 58% respectively for organochlorine and 76% (76% root, 24% shoot), 68% (69% root, 31% shoot), and 70% respectively for pyrethroids. Dissipation rate constant of treatments with plants (T_2, T_3, T_5, T_6, T_8, and T_9) was significantly higher ($p < 0.05$) as compared to

treatments without plants i.e. T_{10} and T_{11} (control) for both organochlorine and pyrethroids. Bioconcentration factor of pyrethroids treatments (T_3, T_6, and T_9) was significantly higher ($p < 0.05$) as compared to that of organochlorine treatments (T_2, T_5 and T_8). The removal efficiency of *E. crassipes*, *P. stratiotes* and algae (*C. sutoria*, *S. sticticum* and *Zygnema sp.*) for pyrethroids was significantly higher ($p < 0.01$) as compared to that of organochlorine. Present study concluded that organochlorine and pyrethroids pesticides were abundantly found in the three aquatic environmental compartments (water, sediments and fish) that may cause a severe ecological risk to humans and other biota due to continuous and irregular use of these chemicals which ultimately add to the river Chenab via surface runoff or atmospheric deposition.

ABSTRACT

Present study was designed to monitor organochlorine and pyrethroids pesticides, possible sources, their spatial and temporal variations, bioaccumulation pattern in fish through water and sediments and human risk assessment. Levels of aldrin, o, p′, DDT p, p′, DDT o, p′, DDE p, p′, DDE, α-Endosulfan, β-Endosulfan from organochlorine and cypermethrin, deltamethrin, permethrin and bifenthrin from pyrethroids class were monitored in the present study. During the study, five fish species, four carnivores (*Channa marulius*, *Anguilla rostrata*, *Channa punctatus* and *Wallagu attu*) and one herbivore (*Labeo boga*) were sampled from the four headworks of the river Chenab. Samples were collected from three major aquatic matrices (water, sediments and fish) from the eight sampling sites situated at Marala, Khanki, Qadirabad and Trimu Headworks of River Chenab, during summer and winter seasons. Prior to analysis, liquid phase extraction technique was applied for water samples while all the collected sediment and fish samples were extracted by Soxhlet Extraction Technique. Samples were then processed to column chromatography for cleanup and analyzed by High Performance Liquid Chromatography (HPLC) after achieving LOD and LOQ and assuring all the quality control procedures. BCF and BSAF were calculated for the presence of relevant pesticides in water, fish and sediments. Human health risk was assessed for organochlorine and pyrethroids pesticides by consuming the contaminated fish. Physical and chemical parameters of both water and sediments collected from all the sampling sites of the river Chenab were determined. Analysis of variance (ANOVA), cluster analysis and PCA were applied for significance, classification of sites and source identification of pesticides. Concentrations of pesticides in surface waters of River Chenab ranged from 15 to165 and 23 to 275 ngL^{-1} for organochlorine and 0.087 to 0.189 and 0.094 to 0.355 μgL^{-1} for pyrethroids during summer and winter seasons, respectively. Among organochlorine pesticides, DDTs exhibited the highest concentration in all water, sediments and fish samples, followed by Endosulfan and then aldrin while from pyrethroids group, deltamethrin showed highest values followed by cypermethrin, permethrin and then bifenthrin in descending order. Concentrations of DDT in water exceeded from the CCC concentration guidelines of USEPA while aldrin levels were higher than the PSQCA set criteria. Concentrations of pesticides in sediments ranged from 4.3 to 156.3 and 8.15 to 239.19 ngg^{-1} for organochlorine and 0.147 to 1.162 and 0.254 to 1.248 μgg^{-1}