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ARE PERFLUORINATED COMPOUNDS A CONCERN IN SOUTH AFRICA? CURRENT LEVELS DETECTED IN WILD BIRD EGGS

C. Swiegelaar[1], L. Quinn[1], D. Prevoo-franzsen[1], H. Bouwman[2]

[1]*National Metrology Institute of South Africa (NMISA), Organic and Bio-analysis Section, CSIR Scientia Campus, Pretoria, South Africa*

[2]*North-West University, Research Unit: Environmental Sciences and Management, Potchefstroom, South Africa*

Introduction:
Perfluorinated compounds (PFCs) are widespread toxic persistent organic pollutants (POPs) that are used extensively in various industrial applications. Contrary to the bio-accumulative pattern of most persistent organic pollutants (POPs) that partition into fatty tissues, PFCs bind to proteins1. Although data concerning PFCs is limited for South Africa, these compounds have been detected in human and avian populations. This study focussed on the analysis of selected PFCs from multiple environmental matrices in the Orange-Senqu River Basin (OSRB), one of the largest river systems in Southern Africa. Matrices were fresh water, sediment, waste streams, fish, and bird eggs. The aim of the project was to determine the levels of 12 PFCs in the OSRB where high levels were found previously, and to establish possible sources, pathways, exposures, and hazards of the PFCs identified and quantified.

Materials and Methods:
Prior to use, all equipment and consumables were pre-cleaned with methanol. Additionally, various blanks were run throughout the analytical procedure to evaluate PFC contamination not only from the extraction and clean-up method but also from the liquid chromatography tandem mass spectrometry (LC-MS/MS) system. The extraction and clean-up methods employed, differed for each matrix. Abiotic samples were extracted using sodium hydroxide followed by weak anion exchange solid phase extraction (SPE), while biotic samples were extracted using methanol in combination with dispersive activated carbon SPE clean-up. Thereafter, the extracts were analysed by LC-MS/MS and levels quantified using isotope dilution mass spectrometry (IDMS) using authentic standards [perfluorobutanesulfonic acid (PFBS), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorohexanesulfonic acid (PFHxS), perflurooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), perfluorododecanoic acid (PFDoA), perfluorotridecanoic acid (PFTrDA) and perfluototetradecanoic acid (PFTA)]. Statistical analyses, including principal component analysis (PCA), were performed using log-transformed data.

Results and Discussion:
To assess the distribution of PFCs within the environment, matrices included water, sediment, fish, and eggs of various bird species. Water samples contained quantifiable levels of PFBS and PFUnA. The presence of these compounds can likely be attributed to use in crop farming, surfactants in mining or in the textiles and upholstery industry. In the case of sediments and tailings, only six samples contained PFCs. In sediment PFOS and PFHxA was detected, and in tailing we found PFHxA and PFOA. Possible sources identified include aviation, mining and waste water treatment plants. None of the fish samples analysed had detectable levels whereas PFCs were detected in all of the bird eggs analysed.

In bird eggs, long-chain PFCs were prevalent, with PFOS the predominant conger in all samples (Figure 1). The distribution of PFCs according to chain length was as follows: long-chained perfluoroalkyl sulfonates (PFSA) > long-chain perfluoroalkyl carboxylates (PFCAs) > short-chain PFSAs > short chain PFCAs. These findings were in agreement with literature that reported the prevalence of long-chain PFCs in biota6, 7. Long-chain PFCs have higher bio-accumulation potential, than short-chain PFCs, and are therefore found more frequently than other PFC congeners. This is likely due to variation in the bio-accumulation potential of PFCs based on their chain length. Although the bio-accumulation potential of short-chain PFCs is lower, with the introduction of regulations for long-chain PFCs there has been an increase in the use of short-chain PFCs as industrial replacements. It is therefore expected that the concentrations of short-chain PFCs will increase within the environment. However, this change is not yet prevalent in the South African environment.

The congener profiles of PFCs in bird eggs were further investigated using principle component analysis (PCA) indicating that PFCs varied depending on species and collection site (Figure 2). Additionally, the concentrations of PFCs differed significantly between species. These differences could be attributed to multiple factors including diet, feeding habitat, and area of sampling as well as differences in toxicokinetics (absorption, distribution, transformation, and elimination) of PFCs.

In conclusion: PFCs are present in the South African environment, with high concentration levels found in bird eggs. Although there is not yet consensus on the toxicological no-observed-effect level (NOELs) for PFCs in birds, the PFC exposure in conjunction with exposure to other POPs9-10 and organic toxicants may have detrimental effects on the South African aquatic bird population. The combined toxicological effect of these chemical loadings on bird populations may be a cause for concern.

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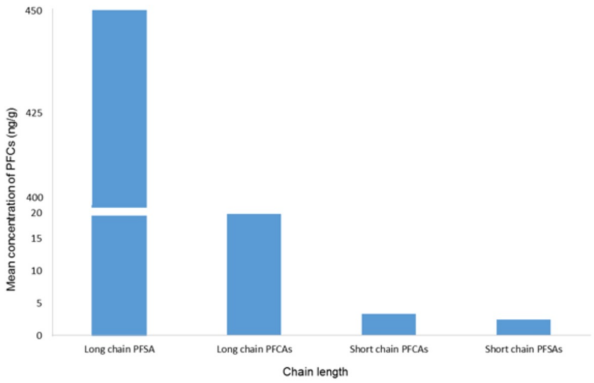

Figure 1: The ΣPFCs distribution according to chain length

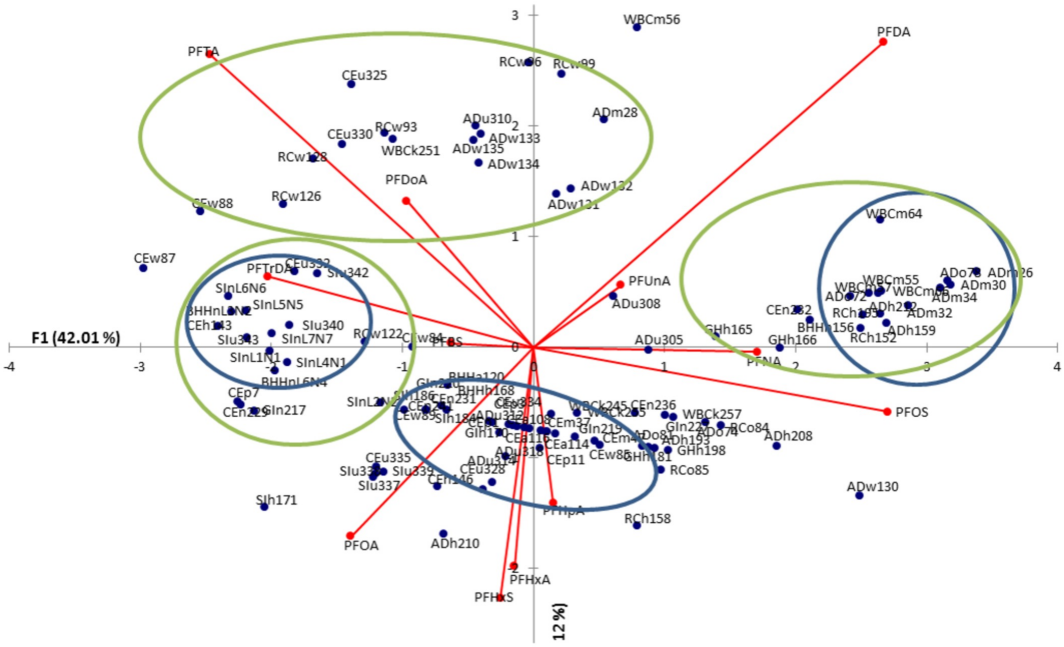

Figure 2: Bi-plot of PCA for PFCs in bird eggs together with bird species (blue) and site groupings (green)