Ecological Issues on the feasibility of managing HFCs: Focus on TFA

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1. Scope of the briefing note

This briefing note focuses on trifluoroacetic acid (TFA) which is one of the main breakdown products for several hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and hydrofluoroolefins (HFOs). The note summarizes key information pertaining to TFA based on recent reports of the Environmental Effects Assessment Panel and the Scientific Assessment Panel of the Montreal Protocol. The issue of TFA in the environment has been assessed regularly by the EEAP and has also been reviewed by other authors. The EEAP intends to provide an updated review of the topic as part of its 2015 Progress Report.

2. Properties and sources of TFA

TFA is the terminal breakdown product for HCFCs (HCFC-123, HCFC-124), HFCs (HFC-125, HFC-134a, HFC 143a, and HFC-227ea), and HFOs (HFO-1234yf). TFA is a very strong acid, which means that it readily forms salts with minerals in soil. TFA is very resistant to breakdown in the ecosystem. Amounts deposited in flowing surface water will ultimately accumulate in the oceans and salt lakes where water is lost only by evaporation. However, based on estimates of current and future use of HFCs, HCFCs, and HFOs, additional inputs to the global oceans, salt lakes and playas will add only fractionally (estimated to be less than 0.1%) to amounts already present from natural sources such as undersea vents and volcanic activity. TFA is terminal breakdown product of other compounds that not regulated under the Montreal Protocol and is also used and as a reagent in biochemistry. Releases from these other sources are unknown.

TFA is stable in the environment but is water soluble and accumulates in playas, land-locked lakes, and the oceans, where it combines with cations such as sodium, potassium, calcium, and magnesium. More than 95% of the salts of TFA found in the oceans are naturally produced. These salts are inert and not of toxicological or environmental concern in the small concentrations that are present in the oceans, playas, and lakes.

TFA, its chemical precursors, and other breakdown products of HFCs, HCFCs, and HFOs are washed from the atmosphere by precipitation and reach surface waters, along with other chemicals washed from the soil. In locations where there is little or no outflow and the only loss of water is via evaporation (playas and salt lakes), the concentrations of these products are expected to increase over time. However, the effects of increased concentrations of other naturally occurring mineral salts and other materials will be much greater and more biologically significant than the breakdown products of the HFCs and HCFCs.

While it is well established that TFA is a ubiquitous natural component in rivers, lakes, and other surface water bodies, uncertainties remain regarding anthropogenic sources, long-term fate and abundances as these are linked to current and future use and emissions of HFCs, HCFCs, and HFOs. Based on estimates to 2040, increases are predicted to remain relatively low and are therefore not expected to be a significant risk to human health or detrimental to the environment.

3. Effects of TFA on humans and the environment

Salts of TFA are not considered as harmful to aquatic life. Toxicity has been tested in laboratory and microcosm studies. The toxicity values for aquatic organisms are in the range of mg/L whereas measured and modelled concentrations in rain are generally a million-fold smaller (ng/L) and after further dilution in flowing surface waters are orders of magnitude less than toxicity values.

Salts of TFA are not considered toxic to terrestrial organisms. TFA-acid is potentially corrosive to the skin but only in concentrations many thousand-fold greater than those found in rainwater. Salts of TFA are essentially non-toxic to mammals with acute LD50 values of greater than 5 g/kg. Because of their high solubility in water and their very small octanol-water partition coefficient, they do not bioconcentrate in aquatic organisms, and do not biomagnify in the food chain. Thus they present negligible risk to organisms higher on the food chain, including humans.

Projected future increased loadings of TFA to playas, land-locked lakes, and the oceans due to continued use of HCFCs, HFCs, and replacement products such as HFOs are still judged to present negligible risks for aquatic organisms and humans.

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