A COMPREHENSIVE STUDY OF THE CHARACTERIZATION OF PARTICULATE MATTER EMISSIONS FROM A DELMARVA BROILER POULTRY OPERATION

by

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ABSTRACT

Particulate matter (PM) emissions from agricultural practices, including those from animal feeding operations (AFO's) have become an increasingly important topic, and has generated considerable interest from local and state agencies, as well as, the local community over the past decade. Because of growth in population, and an increase in commercial and residential development within close proximity to these operations, which house a large number of animals in confinement, and because of a better understanding of the effects of exposure to airborne contaminants on health, this has lead to an increase in concerns and a demand for more research to be conducted on PM from AFO's.

Particulate matter generated within, and emitted from, AFO's can carry with it various components including metals and microorganisms that can negatively affect health. This research was conducted in order to verify if PM from a broiler poultry operation on Delmarva has the potential to become a health concern. The first step was to determine concentrations of two size segregated fractions of PM from indoor and outdoor sampling sites over four seasonal periods, early summer (ES), late summer (LS), Fall (F), and Winter (W). Both PM_{10} and $PM_{2.5}$ were collected because of their classification from the Environmental Protection Agency as having the ability to cause significant health effects with short-term exposure. Next, temporal and spatial characteristics were investigated to determine their effects on PM concentrations over the four seasonal periods. Following this, the chemical composition and morphology of PM_{10} and $PM_{2.5}$ generated from the broiler poultry

operation was investigated. Finally, further detailed information was obtained on arsenic speciation and oxidation state in PM to investigate toxicity. Arsenic use in the poultry industry has been occurring for a number of decades, and is most frequently administered in the organic form. However, studies have shown that these organo-arsenicals can quickly degrade into organic by-products, methylated arsenicals, and inorganic arsenic (III and V). Because oxidation state determines mobility and toxicity in humans, animals, and the environment this is a key reason to investigate it further in PM.

The results from this research indicate that the concentrations of both PM size segregated fractions that were sampled are within the regulatory guidelines of EPA and OSHA. Outdoor concentrations were mainly influenced by wind speed changes over the seasonal periods, and bird weight was the main management factor influencing indoor PM concentrations. In addition, upon performing chemical analysis on the PM using inductively coupled plasma mass spectrometry (ICP-MS), the arsenic concentrations found are not above background ambient arsenic levels for outdoor samples; however, total arsenic was found to be above those background concentrations in both indoor PM_{10} and $PM_{2.5}$ samples. Although the arsenic concentrations were found to be higher than background inside the poultry operation, they are currently within the regulated limits set by the Occupational Safety and Health Administration (OSHA) and the National Institute of Occupational Safety and Health (NIOSH). Other metal(loid)s such as copper, manganese, and zinc were also within regulatory limits in both indoor PM_{10} and $PM_{2.5}$ samples.

While the EPA has National Ambient Air Quality Standards set for PM_{10} and $PM_{2.5,}$ these regulations are not suitable when evaluating indoor occupational

concentrations from an animal feeding operation such as a broiler poultry operation. In addition, the EPA does not currently have standards set for arsenic in ambient or general air pollution. It is also questionable to use the current dust regulations set by the OSHA or NIOSH because they are generalized to two categories that are not easily translatable to the current PM_{10} and $PM_{2.5}$ size segregations accepted under the EPA. In addition, there is an assumption made that particles within their total suspended and respirable regulatory categories are "inert" or nuisance, which infers that particles under this classification would not lead to any significant health problems. This is not the case with PM generated from a broiler poultry operation, which can carry with it a number of contaminants that have been proven to cause various health disorders from exposure. These classifications also apply to inhalable arsenic standards and are also questionable when determining whether arsenic concentrations in PM from a poultry operation are permissible.

Arsenic oxidation state and speciation in PM_{10} and $PM_{2.5}$ was investigated using X-ray absorption spectroscopy (XAS) and X-ray fluorescence (XRF) spectroscopy. The results indicate that there is a mix of organic species present, as well as, oxidized As(V) and reduced As(III) in all samples analyzed. The main organic species found were in the form of Roxarsone, 4-hydroxy-3-aminophenylarsonic acid (HAPA), and dimethylarsinic acid (DMA(V)). This indicates that much of the organic form that was originally administered has degraded into more toxic by-products that are then becoming incorporated into airborne particulate matter.