Salt Water Vapor Discharges and the Environment

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ABSTRACT

Discharges from salt water cooling towers can be evaluated in terms of their two major components, aqueous vapors and ambient particulates.

Both the aqueous vapor and the ambient particulates are typically of colloidal size or larger. Distribution of salt water cooling tower discharges may occur by condensation methods. Condensation generally involves the coalescing of water vapor containing particulates in the form of elemental salts. This concentration method increases the salinity and consequently increases the rate of salts discharged to the surrounding environment.

Sublimation is a means by which the particulate discharges find their way to the environment. Sublimation refers to the hygroscopic characteristics of elemental salt and calcium chloride. After emission from the stack, the calcium and sodium chlorides are in a crystalline elemental form. After this particular point, they find their way through the environment and may be absorbed by moist or humid conditions and therefore, deposited in regions of increased or mesic environmental qualities. Finally, evaporative deposition serves as a means by which elemental salts can be transported and eventually deposited on plant tissue, ground, animals, etc.

The five major environmental pathways of salt water effluents are: soils, plants, terrestrial vertebrates, aquatic organisms and finally, man himself. The physiology of effects of salts on soils and the terrestrial biota is being determined through many programs of testing at the present time. Aquatic organisms and their uptake rates are being studied through water quality programs. The effects of salts on man have been determined and efforts to reduce concentrations of these salts that would be deleterious to cardiovascular systems and hemopoetic systems are being conducted at the present time.

What then are the methods by which control of these discharges can be effectively operated?

First, precipitation offers one answer to the problem. By means of baffles, large amounts of elemental salts can be re-precipitated as they pass through the emission stacks. This re-precipitated salt can be utilized on site for such purposes as deicing.

Accumulation offers another technique. This also involves the baffling system whereby salt deposition can be accomplished through heated baffles which serve to provide surface on which salt crystals can grow.

The elevation dynamics of the stack itself can serve to limit the amount of salt emitted from the tower. The higher the tower, the greater the distance within the tower and correspondingly the greater the percentage of condensation that will occur within the tower itself, can prevent the release of large salt water volumes.

Areas for further study involve the physiological effects on biota of salt and its constituent products. An efficient means of controlling emissions is a keypoint to the development of a cooling tower discharge program that does not have widespread environmental effects. De-salination processes have been tried and efficient means are yet to be developed so that salt from discharge effluents can be usefully removed and utilized in some other aspect of plant operations. The investigation of other cooling methods is at present under consideration and this too should offer an area for further research and development.

INTRODUCTION

Salt water vapor has several sources including ocean spray from the marine environment, salt water vapor produced by desalination plants from their stack effluents, cooling towers in the power industry, spray ponds from the power industry which provide some salt water vapors through evaporation and mining operations which provide salt water vapor from wind ablation and hydraulic spray and through deicing agents for roadway applications.

Salt water vapor discharges include two principal components of concern from an environmental standpoint, aqueous vapors that are generated and ambient particulates. Both of these vapor components are characteristically of colloidal size or larger, i.e., approximately six microns in size. The distribution of salt water vapor usually occurs by means of condensation. Condensation generally involves the coalescing of water vapor and elemental salts in the form of particulates. Another means by which salt vapor is brought into contact with the environment is through the process of sublimation. This is the process by which a dissolved or heated salt solution is first released to the atmosphere, then cooled and reconverted to a solid elemental state.

ENVIRONMENTAL PATHWAYS AND EFFECTS

There are four principal environmental pathways for salt water vapor discharges. First, soils carry salts through solid and liquid salt deposition and accumulation. Secondly, terrestrial plants also carry salts primarily through solid and liquid salt deposition. Thirdly, terrestrial animals are affected, primarily through elemental solid deposition, and fourth, fresh water aquatic organisms are affected through dissolved salt deposition and accumulations. Man, in one form or another, receives the effect of salt vapor discharges, either directly in his diet, or through economic influence on crop plants directly, and livestock secondarily.

SOILS

In soils chloride ion concentrations from 10 to 75 parts per million are acceptable for the normal vigor of most plants produced from cultivation. Accumulations of salt vapor from 100 to 200 parts per million are excessive and cause reduced yield and vigor. Physical and chemical properties of soils change salts. Fortunately salt is rapidly leached from the soil. This is the result of electrochemical action of salt as an electrolyte coursing through the groundwater. However, if precipitation or drainage are lacking, large scale accumulations can occur with deleterious consequences for the soil itself and its associated vegetation cover.

PLANTS

In plants, the effects of salt vapors can be seen primarily as an effect called "burning" or necrosis. Leaves of deciduous species, considered to be the most sensitive to salt, normally are the first to exhibit salt effects by a general burning at the tip and along the margins of the leaves which progresses as the salt injury increases. Buds and twigs, including flowers and fruit, can also be concurrently affected. In the conifers, needle burn necrosis is exhibited from the tip to the rear of each leaf as the injury progresses. Leaf scorch is characteristically exhibited as a change to a straw to orange color as the result of salt poisoning. There are some plants which are highly resistant to scorch by salt; however, for each there is a concentration threshold which when reached decreases plant vigor and eventually plant mortality ensues. Studies by Boyce (1954) have shown that the collecting efficiency in plants for salt varies with their morphology. The finer the leaves, the more efficient the plant becomes as a collector. A particularly appropos example of the effects of marine salt vapor on the vegetative community is cited by Moss (1940). On September 21, 1938, a day that will long be remembered in New England as the day of "the hurricane," a storm transported extensive marine spray to the hardwoods of coastal New England. The full effect of the salt spray damage was not known until the following spring when leaf scorch could be seen in sensitive species as far inland as forty-five miles. This is just one example of some of the pervasive influences that salt vapor can have on a terrestrial plant community.

TERRESTRIAL ANIMALS

In terrestrial animals similar occurrences have been found. In a study by Clark, Rogers and Wolgast (1971), salt poisoning was observed in the field in cottontail rabbits, bobwhite quail, ringnecked pheasant and rock dove. Sub-lethal effects were observed by McNabb (1969), in bobwhite quail when drinking water with one percent dissolved sodium chloride. Many species are able to cope with increased salt accumulation in their diets by increasing their food consumption. In addition to direct salt uptake and poisoning in some species, there is the secondary consequence of a change in available forage vegetation resulting from a lack of plant species which tolerate increased salt levels. The result is that one trophic level in the food web can have a pervasive influence on another level, even though it superficially appears to be quite removed.

AQUATIC ORGANISMS

In fresh water aquatic organisms, the effect of salt is somewhat more varied. In fish, salt poisoning has been observed in many experiments. Changes in iso-osmotic potentials within the individual cell which result from salt uptake actually can cause a dehydration to occur. Additional studies have shown, however, that many species have very wide tolerances for accepting greater salt concentrations for a short period. This fact makes the prediction of specific effects very difficult. In addition to freshwater fish, the phytoplankton and zooplankton exhibit sensitivities to increased salt concentrations. Phytoplankton, according to Ketchum (1953), generally react adversely when salt concentration is increased by ten parts per million over the background concentration. Even more narrow bands of tolerance are encountered with zooplankton, where the range of threshold tolerance to from two to three and one-half parts per million. Therefore, the importance of salt in the freshwater environment is keyed to the salt concentrations in the food chain which limit the carrying capacity for the consumer organisms. The effects of salt water vapor in man are both psychological and physiological. The effect of salt vapor on automobiles, paints, houses and machinery are all well known for their psychological and economic impact. Physiologically, salt causes increased stress to the cardiovascular system, in addition to the changes it causes in the blood chemistry. Whether the increase in salt is the result of ingested food subject to salt spray or by direct inhalation of salt vapor, the effects of salt vapor on man are coming under more intense scrutiny every day.

CONTROL OF SALT VAPOR DISCHARGES

What then are the effective means by which salt vapor discharges can be effectively controlled? For industrial operations, precipitation of salts by cooling systems, wetpacks and filters offer one method of control. Accumulation of salt in baffles and extractors is another means by which the salt vapor can be prevented from release in the atmosphere. Aerosol salt spray systems should be designed so that increased particle size is achieved, thus reducing the airborne and evaporative drift common to spray ponds. In mining operations, dust protectors for large salt cargoes should be used. In addition, modifications should be made in hydraulic spray systems which incorporate nozzles and spray heads having configurations which limit overspray and drift. Stack effluent systems should be developed to trap salt and accumulate it. Deicing agents should be designed using mixtures of elemental salts and other additives which could reduce the roadside salt spray by preventing salt from concentrating or being blown off the roadway and onto adjacent vegetation.

SUMMARY

This paper has briefly considered the effect of salt water vapor on the environment, salt water vapor sources, industries responsible for salt vapor discharges, vapor components, including vapor size and particulates. The distribution criteria have been considered through condensation and sublimation factors. The pathways through which the salt vapor pervades the environment have been discussed, including the role of soil, terrestrial plants and animals, freshwater aquatic organisms and man. Finally, some means of controlling vapors have been discussed. Ultimately there is hope through research for solution to excessive salt spray vapor discharges. There are many possibilities for advanced research on the effects of salt where beneficial results can be achieved through the combined positive efforts of the ecologist and the engineer for the production of a more balanced and productive environment.

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