Excessive Fertilization Water Quality Problems in the Sacramento River Watershed and Delta

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The Problem

The excessive fertilization (eutrophication) of waterbodies is one of the most common significant causes of readily discernible water quality impacts. The excessive growth of aquatic plants (algae and water weeds) is causing impaired water quality in some parts of the Sacramento River watershed, within the Sacramento - San Joaquin River Delta and in water supply reservoirs that utilize Delta waters as a source of supply. Specific problems include impaired use of water in Sacramento River tributaries in the northern watershed, excessive growth of attached algae and floating water weeds (water hyacinths) in the Delta which interfere with recreational use of the Delta. Of particular concern to water utilities is the excessive growth of algae in water supply reservoirs that use Delta waters which lead to severe taste and odor problems, shortened filter runs and increased trihalomethane (THM) precursors which lead to increased chloroform and other potential carcinogens in treated water supplies.

Cause of the Problem

Excessive fertilization of waterbodies by nitrogen and phosphorus compounds can lead to severe water quality deterioration. The chemicals of greatest concern are nitrate, nitrite and ammonia, and to a lesser extent, organic nitrogen. Soluble orthophosphate is the form of phosphorus that is readily usable by algae. Particulate phosphate, such as that associated with erosion, is largely unavailable to support algal growth.

From the limited information available, it appears that the growth of algae and other aquatic plants in the Sacramento River system and Delta is primarily controlled by the addition of nitrate and ammonia to these waters from land runoff/drainage and wastewater discharges. Of particular concern are domestic wastewater additions to the Sacramento River and its tributaries, as well as runoff from cultivated agriculture and dairies. While phosphorus does not appear to be limiting aquatic plant growth, its addition above normal background to the Sacramento River system is a key element in contributing to the excessive fertilization of these waters.

It is well established that there are no single-value nutrient water quality criteria/standards such as a certain concentration of nitrate or phosphate that leads to excessive fertility-induced water quality problems. The impact from nitrogen and/or phosphorus on aquatic plant-related water quality problems depends on a variety of factors such as the concentrations of available forms of nutrients; sunlight duration, intensity and penetration; the morphological and hydrological characteristics of the waterbody; etc. At this time, there is a poor understanding of the sources of nitrogen and phosphorus compounds for the Sacramento River system and Delta and the relationship between current nutrient loads and the water quality use impairments associated with excessive growths of algae and other aquatic plants in these waters. This is an area that needs attention in order to formulate technically valid, cost-effective nutrient control programs to manage the excessive fertilization of the Delta and its tributaries.

The lower parts of the Sacramento River near Sacramento are not experiencing excessive algae and other aquatic plant growth which cause significant impairment to recreational use of these waters or domestic water supply problems. This type of situation is typically found in river systems which can have elevated concentrations of nutrients without experiencing significant water quality problems. The ability of rivers, such as the Sacramento River, to absorb without significant problems high nutrient loads is related to the turbulence of the river which prevents algae from growing to maximum biomass based on the nutrient loads and accumulating near the surface of the water as floating scum.

While not a problem of the Sacramento River system, the upper reaches of the Delta near Stockton in the San Joaquin River system are experiencing excessive algal growth in some areas where there is limited water exchange - flushing that lead to nuisance growths of blue-green algae and low dissolved oxygen conditions which are detrimental to fish populations.

Impacts of Nutrients on Aquatic Ecosystems

The introduction of aquatic plant nutrients to a waterbody, in addition to stimulating the excessive growth of algae, also stimulates fish production. There is a direct relationship between nutrient loads to waterbodies and fish biomass. However, with increasing fertility, especially at high levels, the types of fish that develop tend to be less desirable, such as rough fish - carp. From a fisheries resource manager perspective, the Delta is characterized as having insufficient primary production (algal growth) to support the desired fish populations. This appears to be related to two factors. First, the short residence time of the water within the Delta before it either leaves the Delta through pumping - export to the Central Valley agriculture and southern California or discharge to San Francisco Bay precludes the development of maximum algal growth based on the nutrients available. However, when Delta waters are allowed to stand in water supply reservoirs for extended periods of time, excessive algal growths occur in these waters.

Another factor that appears to be limiting algal growth within the Delta is the reduced light penetration associated with the discharge of Delta island agricultural waters to the

Delta channels which because of the high total organic carbon and its associated color derived from farming of peat soils causes reduced light penetration which slows the rate of algal growth. This may be one of the reasons why the water hyacinths do well in the Delta since they float on the surface.

Another factor that is believed to be influencing secondary and tertiary production (fish growth) in the Delta is the invasion of Delta waters by the Asian clam *Potamocorbula* which covers substantial areas of the bottoms of Delta channels. It is believed that these clams are significantly changing the food web within the Delta which, in turn, could affect the fisheries resources of the Delta through the clams eating algae.

The relationship between nitrogen and phosphorus loads to the Delta and the desirable aquatic resources within the Delta, such as fish populations, is poorly understood. It could be that substantial changes in nutrient loads would have little or no impact on fish and other desirable forms of aquatic life populations. On the other hand, significantly reducing the nutrient loads to the Delta would be in the direction of improving domestic water supply raw water quality for the water utilities that use Delta waters as a source.

Selection of the CALFED Preferred Diversion Alternative. An area of particular concern that needs immediate attention by CALFED before selecting the preferred alternative for diverting Sacramento River water to the Central Valley and southern California is the impact of these diversions on nutrient-caused and other water quality problems in the Delta, northern San Francisco Bay and in the water supply reservoirs that use Delta water as a primary raw water source. The potential alternative of enhanced flow through the Delta or around the Delta in a Peripheral Canal could significantly change nutrient and other pollutant loads to various parts of the Delta, San Francisco Bay and downstream water supply reservoirs. The potential consequences of the altered approaches for diverting Sacramento River water to central and southern California could significantly impact the Delta's water quality. Of particular concern is the impact of altering the nutrient loads to various parts of the Delta and the Bay on eutrophication-related water quality and fisheries resources.

There is an urgent need for CALFED to place as a high priority for attention the reliable preliminary assessment of the potential consequences of each of the proposed diversion alternatives on Delta water quality. This information should be available before a preferred alternative is selected. Further, CALFED should immediately formulate a technical advisory panel that would develop a monitoring and assessment program that would focus on nutrient water quality-related issues within the Delta and downstream water supply reservoirs. This information is of importance to the Sacramento River system watershed stakeholders since some of these stakeholders may be asked to control nutrient inputs to the Sacramento River system which while not causing water quality problems in the main stem of the River above the Delta, are potentially significant causes of problems within the Delta and water supply reservoirs that use the Delta as a water supply source.

Approach Toward Managing the Problem

There is need to quantify the magnitude, extent and duration of excessive fertilization problems within the Sacramento River system, Delta and in downstream reservoirs used for water supply purposes. Within the Delta there is need to initiate a monitoring program on the areal extent of water hyacinth and excessive attached algal growth which impair recreational uses of the Delta. For domestic water supply problems, the frequency and severity of tastes and odors and other problems and the costs associated with their control should be compiled. This information would provide insight into the magnitude of the excessive fertility of the Sacramento River and Delta waters to the use of these waters for domestic water supply purposes.

An assessment of algal available nitrogen and phosphorus loads to various parts of the Sacramento River watershed and the Delta should be undertaken. Further, the factors controlling excessive growths of algae and water hyacinths within those parts of the Sacramento River watershed and Delta that are experiencing excessive aquatic plant growth should be examined. The ultimate goal of this effort is to develop a nutrient load - excessive fertilization water quality response relationship that can be used to begin to predict the impacts of altering nutrient loads on the water quality problems caused by excessive fertility.

Based on an understanding of algal available nutrient loads and their impacts on water quality, it would be possible to assess the potential benefits in reduced water quality deterioration, as well as the detriments to increased fish production associated with controlling nutrient loads from various sources within the Sacramento and San Joaquin River systems and the Delta to various degrees. Nutrient control from both wastewater and agricultural land runoff is practiced in many parts of the world in order to reduce the excessive fertilization of waterbodies. It is estimated that on the order of 100 million people in the world have their wastewaters treated to remove phosphorus and, in some cases, nitrogen compounds to manage excessive fertilization of waterbodies receiving the wastewater discharges. Further, there are substantial areas of the US, such as in the Great Lakes states and the Chesapeake Bay area, as well as in other countries, where nutrient control from agricultural activities is practiced. A review should be conducted to determine the potential benefits of applying techniques that are being used in other areas to the Sacramento River watershed and Delta in order to manage nutrient loads to the Sacramento River system and Delta.

Suggested Approach

Because of the importance of nutrient-related water quality problems within the Delta and for water utilities using Delta waters, CALFED should provide the funds necessary to develop a technical review panel and consultants to assist the panel to examine the nutrient-related water quality problems within the Delta watershed, Delta and downstream of the Delta. The Sacramento River Watershed Toxics and Monitoring Subcommittees should appoint a panel that would, through CALFED support, conduct a critical review of the existing information on nutrient-related water quality problems within the various parts of the Sacramento River watershed as well as downstream within the Delta. The Sacramento River Watershed Program should include review of the

impacts of the nutrients present in the Sacramento River as it enters the Delta since this will become a key issue in justifying any nutrient control programs from Sacramento River watershed sources. The Sacramento River watershed nutrient water quality studies should be closely coordinated with the CALFED activities and should represent the Sacramento River watershed part of the CALFED nutrient water quality studies.

Additional Information

This review is based on a discussion of these issues, "Excessive Fertilization of the Sacramento River Watershed and Delta," currently being developed by Dr. G. Fred Lee. This review contains references to the literature and other information that provides background to the summary generalizations discussed herein. The authors welcome comments or questions on the issues discussed. They are particularly interested in any information that others may have on these issues.

Reference as: "Lee, G.F., and Jones-Lee, A., 'Excessive Fertilization Water Quality Problems in the Sacramento River Watershed and Delta,' G. Fred Lee & Associates, El Macero, CA, June (1998)."