Lethality of a Suspended Clay to a Diverse Selection of Marine and Estuarine Macrofauna

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Abstract. In this investigation, an evaluation was made of the lethality of a suspended clay mineral texturally representative of the sediment-size fraction with which contaminants are most commonly associated. The study involved a phylogenetically diverse selection of marine and estuarine macrofauna. The time-concentration mortality response of 16 species of fish and invertebrates indicated widely differing sensitivities to high concentrations of clay suspended in the water. Organisms restricted to muddy bottoms were found to be very insensitive to high suspended clay concentrations. However, some open water fish, fouling organisms, and sandy bottom epifauna were found to be relatively sensitive. Tolerant species were also identified from these groups.

In a number of studies, various aquatic organisms have been exposed to suspended particulate materials including a variety of processed clay minerals, Fuller's earth, powdered chalk, incinerator ash, coal washings, and glass shards (Herbert and Merkins 1961, Rogers 1969, Sherk et al. 1974, Peddicord et al. 1975). Several investigators have used natural sediments (Wallen 1951, U.S. Fish and Wildlife Service 1970, Schubel and Wang 1973, Peddicord and McFarland 1978). In most cases, these sediments have been sized, dried, or otherwise altered with regard to their physical, chemical, and biological properties before using them in experiments. A comprehensive review of the literature on effects of turbidity and suspended material in relation to dredging in aquatic environments has been prepared by Stern and Stickle (1978).

The different methodologies employed in previous experiments make comparison of results difficult. A variety of techniques have been used to suspend particles, including periodic stirring with intermittent settling, continuous stirring, and mixing by aeration. Almost all laboratory work has been done in closed systems requiring frequent changing of the water with consequent handling of animals and limiting the duration of experimentation.

For the most part, previous studies have not related responses of animals to actual mass concentration of particles in suspension. Most studies relate responses to turbidity, an optical property of water containing suspended material of unknown absolute concentration. The turbidity produced by suspended
particulate matter is influenced by many factors, including particle size, shape, mineralogy, and color. There is no predictable relationship between the turbidities produced by equal mass concentrations of different materials (Pickering 1976). This matter has also been discussed by Kunkle and Comer (1971), who showed that turbidity could be related to the mass concentration of particles only when the particles are of a uniform physical and chemical nature and instruments are calibrated against weighed samples. Turbidity is usually expressed in Jackson or Formazin Turbidity Units or, in earlier work, as equivalent to the turbidity produced by suspensions of the stated concentration of a standard silica flour. The latter is misleading, because statements like "turbidity of 1000 ppm" are easily misinterpreted as indicating a measured mass concentration of particles per unit volume.

Sediments dredged in this country span the range from all sand-gravel-shell down to all silt-clay and may be any combination in between (Boyd et al. 1972). The higher the content of fine particles the sediment may have, the greater will be its surface area, and consequently, the greater the number of sites for adsorption of contaminants. Organic material associated with natural sediments may also adsorb or complex contaminants, as will iron and manganese oxides and hydroxides that exist as discrete particles or fine coatings. Contaminants associated with natural sediments also are dissolved in the interstitial water (Brannon et al. 1976).

All of the above factors greatly complicate the question of the toxicity of sediment-associated pollutants to aquatic organisms. The effect of suspended fine mineral particles alone has not been adequately defined.

The clay fraction of natural sediments is of three general types: kaolinite, illite, and montmorillonite (Boyd et al. 1972). The present research evaluated the impact of suspensions of processed kaolinite, a common sheet-silicate clay mineral, on marine and estuarine macrofauna. Kaolinite occurs in large, pure beds usually as the product of chemical weathering of feldspars, and as such is presumably free of contaminants introduced by man. It was selected for its uniformity of particle size, and permitted study of the lethal effect of suspended particles themselves rather than the combined physical and chemical effects of sediments in various conditions of contamination.

Open water disposal of dredged material frequently produces intermittent, and sometimes sustained, high particulate concentrations in the form of suspended fluid mud on the bottom in the vicinity of disposal operations (May 1973, Barnard 1978, Nichols et al. 1978). Fluid muds are dense suspensions of fine-grained mineral and organic particles ranging in concentration from about 10 to approximately 480 g/L. They occasionally flow outside the boundaries of disposal areas (Nichols et al. 1978) and thus have the potential for ecological harm through invasion of previously unimpacted areas. Concentrations of the suspended clay used in this study were maintained within the range of concentrations of fluid mud observed in the field. Many of the organisms included here may be subjected to such conditions in their natural habitat.

Materials and Methods

The laboratory system used in this study has been described in detail elsewhere (Peddicord in press, Peddicord and McFarland 1978). It was a flow-through system of 16 hemispherical 75-L