CHEMICAL CONTAMINATION

Modern Biocides — A New Dimension To Water's Complex Environment

by DR. CHARLES R. WALKER
Chief, Branch of Pest Control Research
Division of Fishery Research
Washington, D. C.

. . . . We are still in the "cave man era" and our management tools are as crude as the stone axe or use of fire . . . .

WATER alone, without chemicals, is a sterile environment or "biological desert" and is unable to support many beneficial uses. Life can survive after very specific combinations of chemicals are "added," and only then can "selected" organisms tolerate this environment and grow, reproduce, and sustain a viable population. What may be a needed level of an "essential element" or "chemical condition" to one organism in one geographic location may be the demise of another organism elsewhere. Even the diversity of species and the population density of individual species vary according to these chemical constituents, both in kind and quantity, within specific ranges in concentration.

Thus, a critical relationship in the chemical character of water exists at all times with respect to both the plant and animal life it supports. Small, temporary shifts in the chemical constituents and/or changes in physical conditions, such as light and temperature associated with diurnal or seasonal variations, may pose serious limiting factors to populations.

The dependency of animal life on plant life and specialization of food habits further complicates this picture of the aquatic ecosystem.

The development of modern biocides has brought a new and very important change in the dimension of chemicals and their potential effects on the aquatic ecosystem—both for beneficial and harmful consequences. If the contaminates are toxic and persistent, they can create havoc, particularly on the more fragile organisms of the ecosystem—and many changes in species composition are seldom observed or measurable in terms of the species that dominate the population. Only with highly sophisticated biochemical, physiological, and ecological investigations have our scientists been able to ascertain the significance of the chemicals and effects on each species, the community microcosms, the interrelationship and dependence among organisms, and the flow of energy within the complex aquatic ecosystem.

What then is a contaminate of the aquatic ecosystem? There are probably as many definitions as contaminates. Webster's definition suggests *to make impure, unclean, pollute, corrupt, complete befoulment or decay*. If a substance is "out of place" by its presence or quantity or causes an undesirable effect, it certainly fits my description of a contaminant. This permits the use of chemicals such as fertilizers and even pesticides — provided we are willing to accept their effects on the aquatic environment as beneficial. We can argue that plant nutrients can increase fish production, that aquatic herbicides can improve fish and wildlife habitat, that certain pesticides can control "biological contaminates" such as invertebrates and vertebrates that are nuisance species, disease vectors, unwelcome competitors, or parasites. We feel justified in their use to provide better fish, hunting, and aesthetic qual-

(continued on page 24)

WATER'S COMPLEX ENVIRONMENT *(from page 14)*

ity for our recreational enjoyment. This requires an intensive research program and orderly system of toxicological screening and evaluation of all chemicals and biological components of the aquatic ecosystem.

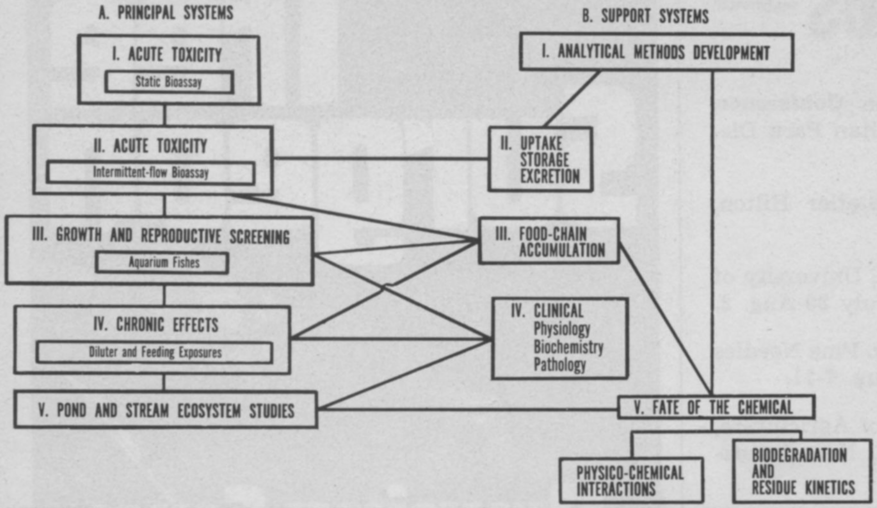
Our research activity routinely concentrates on 1) acute and chronic toxicity of all life stages of fish, fish food organisms, and aquatic flora; 2) fate of residues, degradation products, and their biological significance; 3) conditions affecting toxicity, efficacy and persistence, 4) interaction with other chemicals, components of aquatic ecosystem or physical conditions; and 5) alternatives for biological, cultural, or integrated control methods. (See Figure 1, page 40) As the major resource management agency concerned with aquatic habitat improvement, this information generated by research is required for adequate pesticide labeling, recommendations, and guidelines for safe and effective use of chemicals, biological or integrated control systems.

We have repeatedly demonstrated the more persistent organochlorine insecticides are more toxic than organophosphorus insecticides to fish. Our Fish-Pesticide Research Laboratory also finds that fish-food organisms are quite sensitive to many kinds of pesticides. Field studies confirm these data to a reasonable extent when degradation and exposure-contact time are fully appreciated. With this in mind, biologists are understandably alarmed over decisions to use pesticides and pest control programs when the consideration is cost-effectiveness relative to the pest and safety to humans without recognition of toxicity and residue problems threatening fish and wildlife. Biologists as Rachel Carson have been accused of being emotional and unscientific in their attack. Consequently, many studies on the toxicology of pesticides have been challenged or ignored by those responsible for administrative decisions in the use or labeling of pesticides. We welcome the critical examination of these studies, but we also insist on an equally critical examination of proof that the pest control program *will not adversely affect fish and wildlife.*

Also, we insist that where mounting evidence demonstrates many of these pesticides to be undesirable or suspected contaminates of the environment, we should call a halt to their use until proven safe. This applies particularly to those uses in or around aquatic sites since residues have repeatedly shown up in fish and invertebrates. This is most serious for those chemicals that tend to accumulate in high concentrations in fish-food organisms and fish tissues. Biological transfer of pesticide residues, especially in resistant species, from lower food chain organisms up the food chain to fish, also has been well documented. The most resistant individuals that survive are subject to accumulation and transference of pesticide residues to other members of the ecosystem and to man. The resulting chronic toxicity and residues depreciates the productivity of fish and the value of the fishery — these effects are often subtle and unnoticed. More recently, our attention has turned to the organophosphorous and carbamate insecticides and their interaction with organochlorine pesticides and other compounds such as plasticizers like phthalate esters and PCBs (Polychlorinated biphenyls). These chemicals can kill fish outright, result in tissue residues or cause pathology

(continued on page 40)

Table 1. The Organization of Research Activities at the Fish-Pesticide Research Laboratory.



WATER'S COMPLEX ENVIRONMENT *(from page 24)*

teratogenicity or reproductive failure.

Herbicides also have rated more attention since the controversy on 2,4,5-T and the contaminant dioxin induced abnormal fetuses in special strains of mice. Since some herbicides are used directly in water for control of aquatic plants to enhance fish production and the sport fishery, our investigations center on the fate of herbicide residues and effects on fish, fish-food organisms, and other aquatic organisms.

We have studied the effects of certain pesticides on the aquatic ecosystem in relation to maximizing production of sport fish populations. Antimycin, a potent fish toxicant that is a short-lived and non-residue producing chemical, has been used effectively to alter the structure of bass-bluegill populations. We have used this selective pesticide to thin out stunted bluegill populations and reinstitute a desirable predator-prey relationship to improve the quality of the fishery. This chemical affects only certain secondary and tertiary consumers in the aquatic ecosystem.

Organochlorine insecticides are non-selective; toxaphene, for example, has been used in a similar manner except the primary consumers (fish food organisms) are also decimated. These insecticides are highly lipid-soluble, and their residues linger — readily available to be biologically transferred up the food chain and accumulate in tissues of fish and other predators.

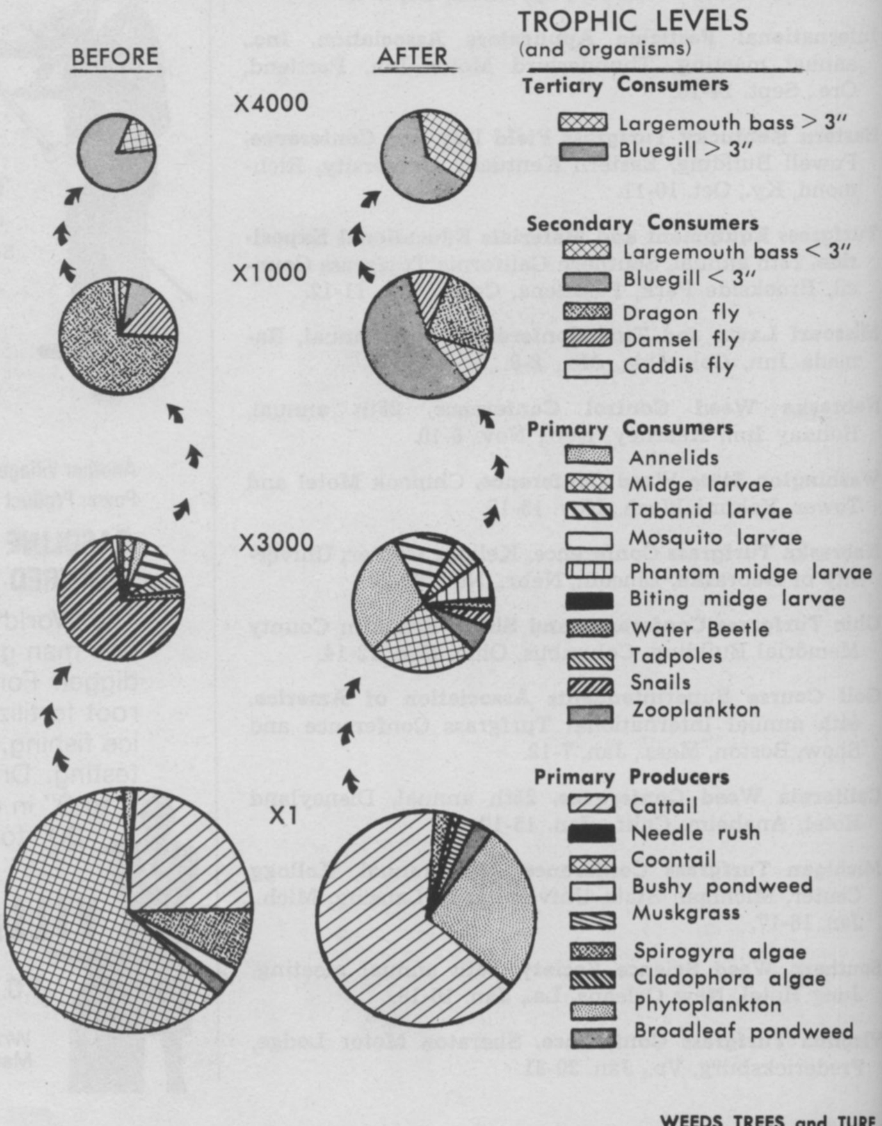
Herbicides are generally short-lived but have a much more subtle effect on the aquatic ecosystem. The aquatic plants or primary producer organisms are directly affected, as is the objective of the management biologists, although very frankly I feel that we are still in the "cave man era" and our management tools are often as crude as the stone axe or use of fire. The changes induced, however, are transferred all the way up the food chain and dramatically alter the flow of energy.

For example, sodium endothall is selectively toxic to certain submersed rooted plants and eliminates them from the habitat — releases these stored nutrients and energy to decomposer organisms (bacteria, etc.) which in turn feed diatoms, rotifers, protozoans, etc. (Figure 2)

This also changes some of the physical features of the habitat — weed clinging insect larvae and protective cover for the invertebrates and small fish are now more vulnerable to predation. Turbidity from the plankton is sharply increased but does not adversely affect feeding by predator-size fishes at the secondary and tertiary trophic level. The net result is a more efficient system for benefiting the desirable sport fishes. Removal of excessive plant growth redirects energy flow and

(continued on page 51)

Table 2. Before and After Effects of 0.5 ppm disodium endothall on the specides composition and production of biomass in a 0.25 A pond ecosystem.



WATER'S COMPLEX ENVIRONMENT *(from page 40)*

improves fish growth rates — increases in production and catch per unit effort are evidence of improvement in the sport fishery.

There are those who look critically at technological innovations — oppressed by fear of deterioration of the environment. They are somewhat justified by numerous examples, even though many are exceptions to general rule. In the meantime, the air becomes polluted with the exchange of emotional charges followed by the frustrations, despondency or apathy of the public or officials to find solutions to the "problems."

They seriously question man's responsible relation with the native flora and wildlife of this earth . . . and logically question if these are the same people who plunder for sake of profit and deny these forms of life a share of the environment based solely on materialistic cost-benefit ratios. These repeated cries of alarm about our environmental crisis are similar to the Aesop Fable of the boy who cried wolf — unfortunately, well-meaning scientists also sound alarms, and often about matters far removed from their own special area of competence.

Is it any wonder that the public becomes disillusioned with science and scientists — and then suspicious of our technological improvements? We have enough anti-intellectualism without precipitating such a dominant force that may well result when we allow spirited scientific debate to escape these halls to the public arena. Our understanding is based upon respect for different viewpoints but with critical evaluation subjected by the multidisciplinary scientific commmunity. The work and opinions of some colleagues have been exploited and eventually become subjected to the "headline hunting."

Thus, we cannot afford to ignore the special responsibility of the scientific community to both consider the "good" and the "adverse" effects of chemicals as contaminates.

Preview

For

August

Shade

Tree

Spectacular