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CURRENT USE PESTICIDES IN HIGH-ELEVATION NATIONAL PARKS IN THE WESTERN US

INTRODUCTION

National Parks are meant to be untouched, protected areas. Unfortunately, it has been shown that detectable levels of pesticides have been appearing in high elevation National Parks. This is worrisome, because the pesticides are not actually being used in these National Parks. Instead, the pesticides are used far from national parks and are being "delivered" to these high elevations through precipitation where they are accumulating (1-4). As a supposed "protected area", it could be considered counterproductive to allow the deposit of these pesticides to continue and could have negative effects (5-7).

Use of pesticides has become concerning, as many appear to be endocrine disrupting chemicals (EDCs). EDCs are chemicals that disrupt an organism's natural endocrine system function in any way, and could therefore disrupt natural reproductive organs or behaviors and metabolism among many other possible effects (1,8,9). Even if not known to be an EDC, many pesticides have been identified as carcinogens (1), and are not to be taken lightly. For some pesticides/herbicides, such as atrazine, the mechanism of action is known (1,8), but for many others, it is currently unknown, but still possibly linked to the disappearance of some animal species (5, 7, 9). Sometimes, these endocrine disrupting pesticides have the highest effects are lower levels (9). Therefore, the deposit of pesticides is not only worrisome for it's insect exterminating qualities, but also for the possible long-term effects on aquatic populations, such as fish or amphibians.

ACCUMULATION

Due to diurnal winds and cold temperatures, high elevations are prone to the accumulation of pesticides through precipitation (10). Some mountainous areas can be more prone due to the shape of the mountain, which can "cup" the winds promoting precipitation on a specific area (10,11). The pesticides will remain on the mountains as snowpack, streams, ponds, and sediment (1,12,13). Because pesticides were made to be shelf-stable products, they are usually very stable molecules that have long half-lives, and will remain in the environment for an extended amount of time. The cold temperatures also help to preserve the molecules, preventing molecular degradation. Thus accumulation of these pesticides is occurring, and this accumulation is reflected by increasing physiological levels in aquatic organisms like fish (1,6).

Of the fish tested for pesticide contaminates, just over half of them were detected to have higher contamination than considered safe physiological exposure level for recreational fishing (which is one magnitude larger than subsistence fish), as established by the Environmental Protection Agency (EPA) (1,6). This insight to fish contamination is only a snapshot of what is occurring, and it is unclear if the levels of contamination are stable or increasing. The levels of contamination should be continued to be monitored, including the possible carcinogenic and endocrine disrupting effects on the fish.

The next level of concern is bioaccumulation. Despite the fish pesticide contamination level being above safety thresholds, there isn't really anything National Park officials can do. Subsistence fisherman will continue to fish, and wildlife will still continue to consume the fish. This past year, 20 grizzly bears along Western US and Canada were tested for mercury (also delivered there through precipitation), and 14 of the bears tested positive for mercury in levels

exceeding the safety threshold for polar bears (14). The study found that the bears accumulated mercury *daily* from ingesting contamination salmon (14). If this kind of accumulation is occurring so rapidly with mercury, it is almost certain these bears are also being exposed to "relocated" pesticides, and possibly accumulating them as well.

A survey in 2010 showed accumulation of pesticides in vegetation through the uptake of polluted water, and through water storage can be a source of accumulation (15). Because plants have a vastly different hormone system than that of vertebrates, it is less likely the plants will be show the effects these pesticides, especially since pesticides are usually used to protect plants. However, bioaccumulation in plants does raise concern for the herbivores consuming them (15).

With wildlife consistently exposed to multiple pesticides, there is unease in term of the potential effects. Individually, the effects of these contaminants are usually known, and used to determine safety thresholds of exposure. However, these thresholds are determined on an individual contaminant basis; they are not evaluated in a synergistic manner. Therefore, an exposure level that is considered to be "safe" may only be safe if exposed to a single pesticide, and the combined effects of several pesticides may be detrimental to a species.

IN PRECIPITATION

It is somewhat frightening to learn that pesticides are present not only in urban runoff, but also transported by precipitation in the forms of rain, sleet, snow, and hail. Not only are pesticides appearing on rooftops in urban areas, but are also being transported hundreds of miles by high winds, and then deposited in national park areas (16). Each year, as pesticides are

reapplied, they are appearing in precipitation, with concentration varying based on amount of precipitation (5).

Also, as aforementioned, the Western U.S. national parks are prone to precipitation due to diurnal winds, cold temperatures, and high elevations with formations that may help "cup" the precipitation (10,11). More precipitation means an increase in contaminated rain and snow (1).

Recent research has shown that pyrethroid pesticides can be absorbed through the skin of mammals (17). Pyrethroid pesticides have the largest effects per unit of concentration (18), meaning a little goes a long way in terms of effects. One study finds that this absorption is almost entirely eliminated if washing the infected area (17), however this is not a doable solution for national park managers. Therefore, even if these animals are not consuming polluted water, plants, or fish, they are still being exposed by being rained on. No wildlife will go untouched by pesticides.

PHYSIOLOGICAL EFFECTS

In 2010, the EPA did a contaminant survey along the west coast evaluating airborne pesticides, they found out of 31 sites, 6 contained intersex fish. Intersex fish are fish with the presence of both male and female reproductive structures (i.e. testicles filled with eggs). The appearance of intersex fish and amphibians is a common biological marker for estrogen-mimicking and testosterone aromatizing chemicals (aromatizes testosterone into estrogen creating excess estrogen), which many pesticides are known to be (15). Intersex fish typically cannot reproduce and can cause population diminishment (5-7,9,15).

To an extent, exposed vertebrates can compensate for pesticide effects due to increased estrogen (synthetic or synthesized from testosterone aromatizers) by decreasing the amount of estrogen produced. However, once the body ceases to make estrogen, and external levels continue to rise, the organism will begin to display signs of excess estrogen. In males, minimal signs would be the appearance of secondary sexual characteristics (19). Feminization of males can disrupt mating behaviors, especially if female choice is involved. Exogenous estrogen can also cause the decrease of reproductive behaviors and result in the cessation of reproduction (19). Continued exposure would be changes in sex ratios, the presence of an intersex, and the disruption of the physiological reproductive cycle (15). Developing organisms are especially susceptible to these effects in an often-irreversible manner.

In female vertebrates, exogenous estrogen can be considered a carcinogen, as it promotes estrogen dependent cancers. As stable molecule, these synthetic estrogens often last longer in the body for potential use (20).

One type of pesticide, organophosphates can act as acetylcholinesterase (AChE), which when absorbed acts as a muscle relaxant (18). When exposed in high doses, AChE can relax vital muscles such as the diaphragm causing the organism to suffocate.

Some pesticides have even been shown to reduce photosynthesis in plants (18).

All of these effects can appear in the national park wildlife, with no way to combat their source.

PESTICIDES OF CONCERN

There are hundreds of pesticides present in the environment. Some having been banned 20-30 years ago are still present and showing hazardous effects. There are a wide variety

including, but not limited to: organophosphate, chlordane, and dieldrin (15,18). These particular pesticides are each known to contain acetylcholinesterase, estrogen-mimicking, testosterone aromatizing, carcinogenic, or a combination of these characteristics.

CASCADE OF EFFECTS

Pesticides delivered to national parks have already been linked to the disappearance of sensitive amphibian species in national parks (5). As accumulation increases, aquatic species are increasingly in danger of contamination to the extent of population diminishment (5,18). The loss of these amphibians could have “bottom up” effects on the food web but reducing the food sources for larger mammals (21). From this, the effects of pesticides could highly impair an ecosystem.

CONCLUSION

In total, we are seeing that our national parks are being exposed to pesticides through precipitation, drinking water, plant consumption, and fish consumption all due to contaminated precipitation (1-4,6,8,14,15). National parks are an indicator for the health of the earth as “untouched” and “preserved areas”. Their state of health reflects directly the state of environment as a whole. The only way to cease the pesticide contamination of national parks is to cease their use. Once in the environment, these pesticides are unavoidable. Paired with high elevation, high winds, and cold temperatures, these pesticides are not only being deposited in our national parks, but accumulating in them. If we are unable to protect these reserves of wildlife and plants from contamination, then there is no longer a way to keep a true preservation of nature.

This is a slow danger. By the time we see the effects it will be too late. The young will be already have been affected and if they are unable to reproduce, that species will no longer exist in that national park. If our national parks are not safe for wildlife, then there is nowhere safe for them at all. The effects could be disastrous and cascade through the food web. At this point in time, pesticide contamination cannot be undone. The pesticide's stable molecules will cause them to remain for years (1), and there is yet to be a way to get rid of them.

FUTURE RESEARCH

Based on current research, unless pesticide use ceases immediately, research should be done to seek alternative pesticides. Pesticide that don't last as long would still allow farmers to use pesticides, but their life in the environment would be much shorter, and hopefully have less effects. Research should also be done to seek out decontamination practices for the lakes and sediment accumulating pesticides. Research has shown that reversal of these effects is possible (22). The synergistic effects of these pesticides should also be studied to develop new thresholds and determine how much longer we have before pesticides have irreversible effects on populations. The runoff from these high elevation areas should be monitored as well. Often, certain chemicals, such as synthetic estrogens are not filtered out of public water supply, and could be affecting human health.

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