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THE IMPACT OF LANDUSE ON SURFACE WATER QUALITY IN QUEENS COUNTY, NEW YORK

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Community water supplies throughout the United States are under increasing threat of contamination from agricultural and urban use of fertilizers and pesticides. Water samples were collected and analyzed in the field from six ponds and lakes from Queens County, New York. The concentrations of dissolved oxygen, chlorine, phosphate, ammonia, and nitrate were determined. Several types of landuse around these water bodies were identified. Our analyses indicate that a relationship exists between the agrochemicals (nitrate, phosphate, and ammonia) found in the water and the landuse in Queens County.

INTRODUCTION

Groundwater is the sole source of water supply for more than 500,000 people in eastern Queens County (Buxton and Smolensky, 1999). The aquifer is recharged from the surface by precipitation and infiltration. Industrial and agricultural (pesticides and fertilizers) contaminants along with septic tank systems have impacted the surface and groundwater quality in this region. For example, high levels of nitrate and pesticide in groundwater and surface water have been reported in Nassau and Suffolk Counties in Long Island (Philips et al., 1999; Flipse et al., 1984).

Surface water and shallow groundwater qualities are affected by human activities. Land-use patterns reflect both the kind and the intensity of these activities. Thus, it is important that the relationship between the landuse around a water body and the quality of water is investigated.

The purpose of this paper is to determine the effect of land use on the quality of surface water in Queens County, New York by utilizing simple hydro-chemical field equipment.

METHODS

Water Chemistry

Five large surface water bodies (lakes and ponds) in Queens County, New York were selected for this study (Figure 1). Water samples were collected from these lakes and ponds and analyzed in the field by using CHEMets® water test kits for dissolved oxygen, chlorine, phosphate,

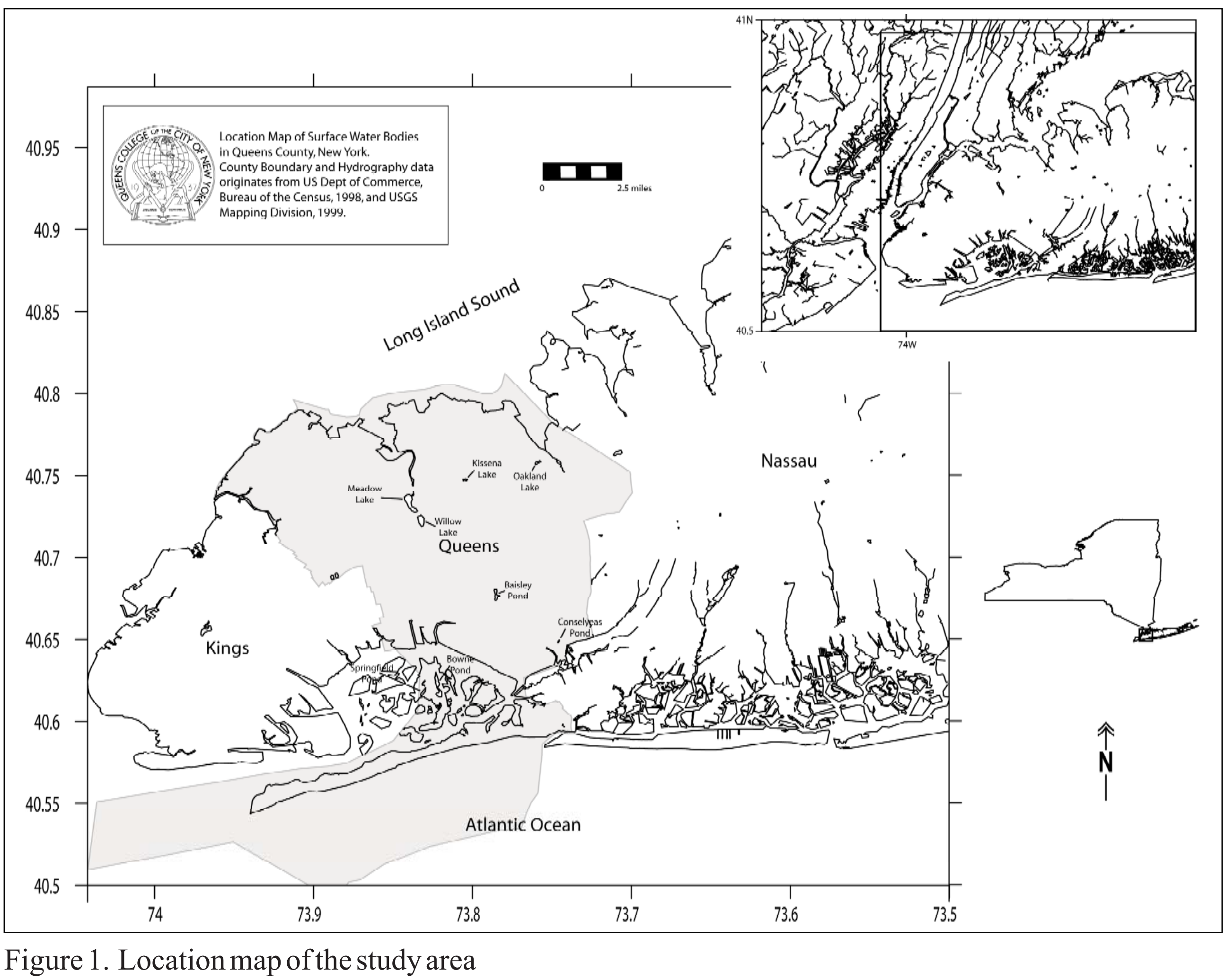

Figure 1. Location map of the study area

ammonia, and nitrate. The CHEMets test kits (Chemetrics, Inc., 2002) are one of the fastest and easiest methods for routine field determinations of these constituents. This method uses vacuum-sealed ampoules containing the necessary reagents. The pre-scored ampoules are inserted into a snap cup filled with water sample. The water is drawn into the ampoule by snapping the tip in the cup, causing a color change that is compared with the given color charts to determine concentration. These concentrations were reported in mg/L (Table 1).

Landuse

Two-mile (3.3 km) wide buffer zones around these ponds were used to determine the landuse. Topographic maps along with local survey were utilized to classify the landuse in six different categories (Table 2). The majority of the landuse identified in the buffer zone are houses, houses with lawns/gardens, parks and apartment buildings. The houses with lawns were included because of the potential use of fertilizers and herbicides in this area. The landuse is expressed as a percentage. The percent landuse was compared with water chemistry to determine any possible correlation by using Microsoft Excel software.

RESULTS AND DISCUSSION

Nitrate

Nitrogen-containing compounds act as nutrients in streams, rivers, and reservoirs. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes (including birds and fish), runoff from fertilized agricultural field and lawns and discharges from car exhausts (EPA, 2002; Kehew, 2001; Koplin et al., 1994). Bacteria in water quickly convert nitrites (NO_2) to nitrates (NO_3) and this process uses up oxygen.

Table 1. Concentrations of different constituents

Ponds	Latitude	Longitude	DO (mg/L)	Cl (mg/L)	Fe (mg/L)	PO_4 (mg/L)	NH_4 (mg/L)	NO_3 (mg/L)
Baisley Pond	40.678ºN	73.786ºW	10	0	0.1	0.1	0.1	0
Conselyeas Pond	40.659ºN	73.746ºW	6	0	0.1	0.1	0.2	2.5
Bowne Pond	40.626ºN	73.823ºW	8	0	0	1	0.2	0
Kissena Lake	40.748ºN	73.806ºW	8	0	0	0.8	0.1	0
Meadow Lake	40.734ºN	73.841ºW	12	0	0.1	0.1	0.6	0
Oakland Lake	40.759ºN	73.760ºW	10	0	0.1	0	0.1	0
Springfield Pond	40.618ºN	73.831ºW	10	0	0.2	0.1	0.2	1
Willow Lake	40.724ºN	73.833ºW	5	0	0.1	0.4	0.4	0

Table 2. Landuse classification

	Land Use								
Pond	Park	Houses	Houses with Lawns	Apartment Buildings	Major Highway	Airport	Shopping	Schools	Other
Baisley Pond	20%	60%		20%					
Conselyeas Pond	25%	15%	50%	10%					
Bowne Pond	5%	10%	85%						
Kissena Lake	45%	35%							Cemetery - 20%
Meadow Lake	25%			50%	5%				Cemetery - 20%
Oakland Lake	10%	10%	80%						Hotels - 10%
Springfield Pond	15%	20%	40%			5%	15%	5%	
Willow Lake	20%^		40%	35%	5%				

The major impact of nitrates/nitrites on fresh water bodies is that of enrichment or fertilization and is referred to as eutrophication. Nitrates stimulate the growth of algae and other plankton, which provide food for higher organisms (invertebrates and fish); however an excess of nitrogen can cause overproduction of plankton and as they die and decompose they use up the oxygen, which causes other oxygen-dependent organisms such as fish to die.

Among the six ponds, Conselyeas pond and Springfield Pond had relatively higher nitrate concentrations of 2.5 mg/L and 1 mg/L respectively (Figure 2). The landuse patterns around these ponds are very similar (Table 2). The Conselyeas Pond has 50% houses with lawns and 25% with park and Springfield Pond has 40% houses with gardens and 15% with park. These higher nitrate concentrations could be attributed to fertilizer use in the parks and lawns.

Ammonia

Ammonia is used in fertilizers either as the compound itself or as ammonium salts such as sulfate and nitrate (EPA, 2002). Since ammonia is a decomposition product from urea and protein, it is found in domestic wastewater. Aquatic life and fish also contribute to ammonia levels in streams and ponds.

Meadow Lake had the highest ammonia content of 0.6 mg/L (Figure 3). The land use around Meadow Lake is 25% park and 20% houses with gardens (Table 2). The observed level of ammonia is attributed to fertilizers that may be used in vegetable gardens or flower gardens. This high level of ammonia can be toxic to the fresh water organisms living in Meadow Lake.

Willow Lake had 0.4 mg/L ammonia (Figure 3). The land use around Willow Lake is 40% houses with lawns, 20% park, and 15% houses with gardens. The ammonia levels are probably due to the fertilizers that might be used in vegetable gardens or that used on grass.

Phosphates

Rainfall can cause varying amounts of phosphates to wash from farm soils into nearby waterways. Phosphate will stimulate the growth of plankton and the aquatic plants, which provide food for fish. This may cause an increase in the fish population and improve the overall water quality. However excess of phosphate entering the waterway can cause eutrophication. Lawn and

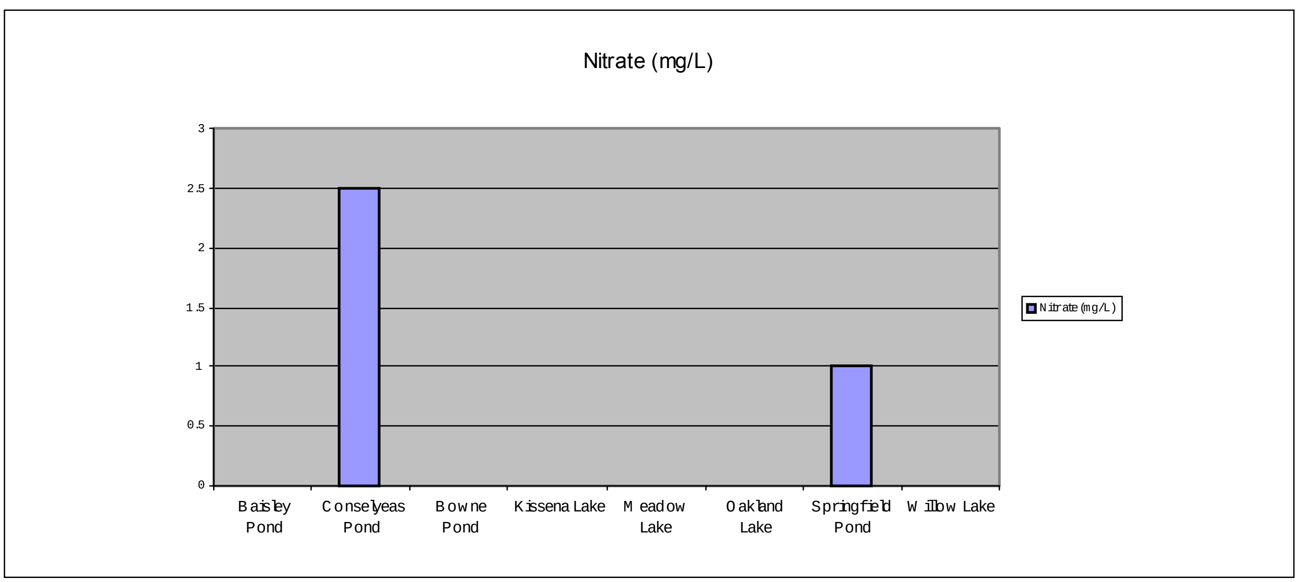

Figure 2. Histogram showing nitrate concentration

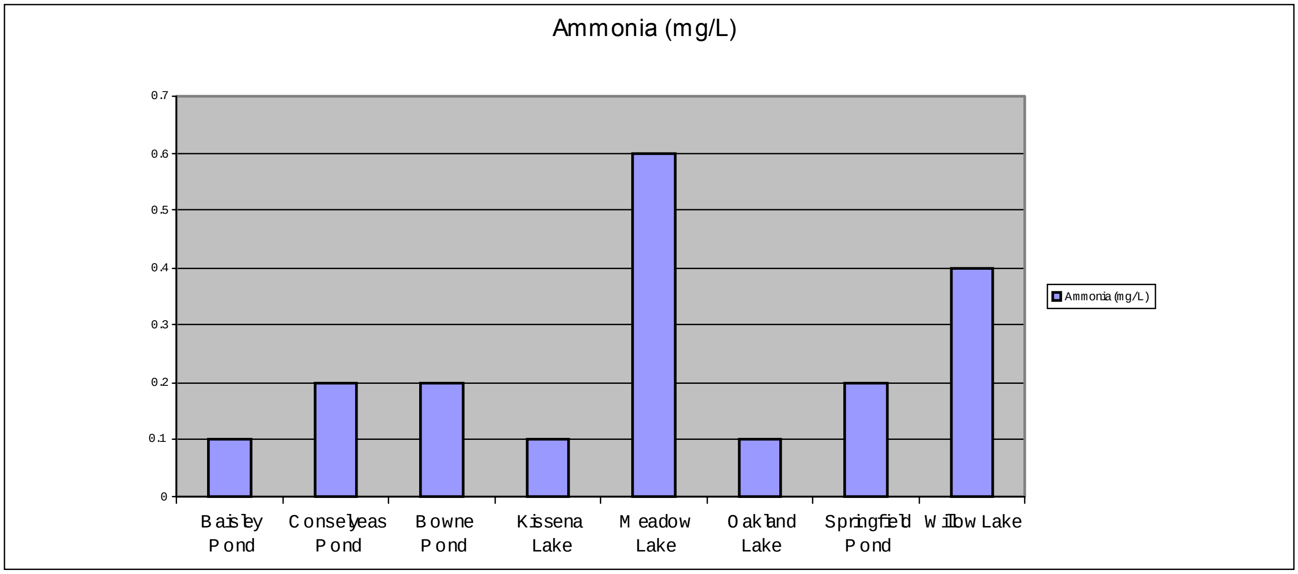

Figure 3. Concentration distribution of ammonia

garden fertilizers often are implicated as the major source of phosphate in the environment. Soil-bound phosphates contribute to pollution only when soil erosion occurs. Problems arise when fertilizer is overspread or spilled onto hard surfaces like streets, driveways and sidewalks. Here, the phosphate washes with rain through the storm drains into lakes and rivers.

Likewise, grass clippings and leaves that fall on hard surfaces release their phosphorous into water sources. Research indicates that 80 percent of the phosphorous from urban settings comes from lawn clippings and leaves that end up in street gutters (EPA, 2002; Miller, 2001). While a few grass clippings mowed into the street look rather innocent, collectively they have a major impact on our water quality.

Bowne Pond, Kissena Lake and Willow Lake showed relatively higher phosphate concentrations of 1 mg/L, 0.8 mg/L and 0.4 mg/L respectively (Figure 4). Land use around these ponds are primarily houses with lawns and park (Table 2). These higher concentrations were probably due to fertilizers that may be used in vegetable gardens, flower gardens and on grass.

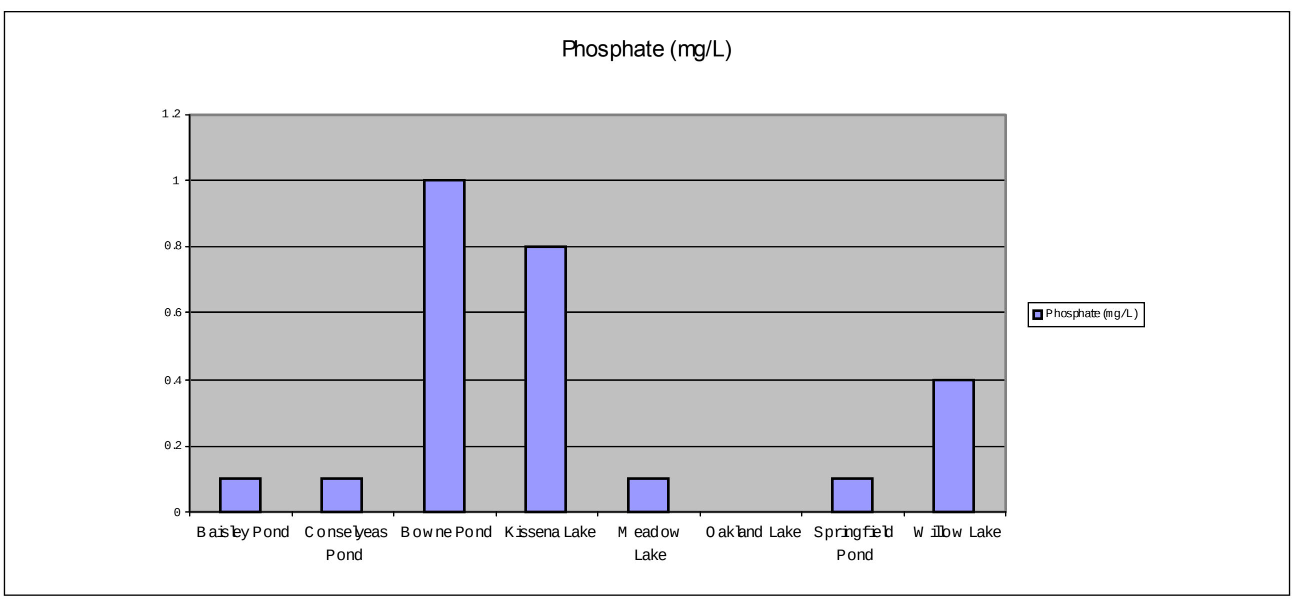

Figure 4. Histogram showing phosphate concentration

Dissolved Oxygen

Dissolved oxygen (DO) analysis measures the amount of gaseous oxygen (O_2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis (Miller, 2001). Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Total dissolved gas concentrations in water should be around 10 mg/L. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The lower the concentration, the greater is the stress. Oxygen losses readily occur when water temperatures rise, when plants and animals respire, and when microbes aerobically decompose organic matter (eutrophication).

Willow Lake had a low dissolve oxygen level of 5.0 mg/L (Figure 5). The landuse that comprises of houses with lawns (60%), parks (20%) and highway (5%) is probably among the contributing factors of this low DO concentration.

Chloride

Chloride is a salt compound resulting from the combination of the gas chlorine and a metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride ($MgCl_2$) (Miller, 2001). Chlorine alone is highly toxic, and it is often used as a disinfectant. In combination with a metal such as sodium it becomes essential for life. Small amounts of chlorides are required for normal cell functions in plant and animal life.

Chlorides may get into surface water from several sources including: road salt, rocks containing chlorides, agricultural runoff, wastewater from industries, oil well wastes, and effluent from wastewater treatment plants.

The chloride level is expected to be high in the winter or early spring because of the salt used on the roads when it snows. Since these samples were taken in the summer there was no chlorine (within the detection limit of 0.05 mg/L) found in any of the water samples.

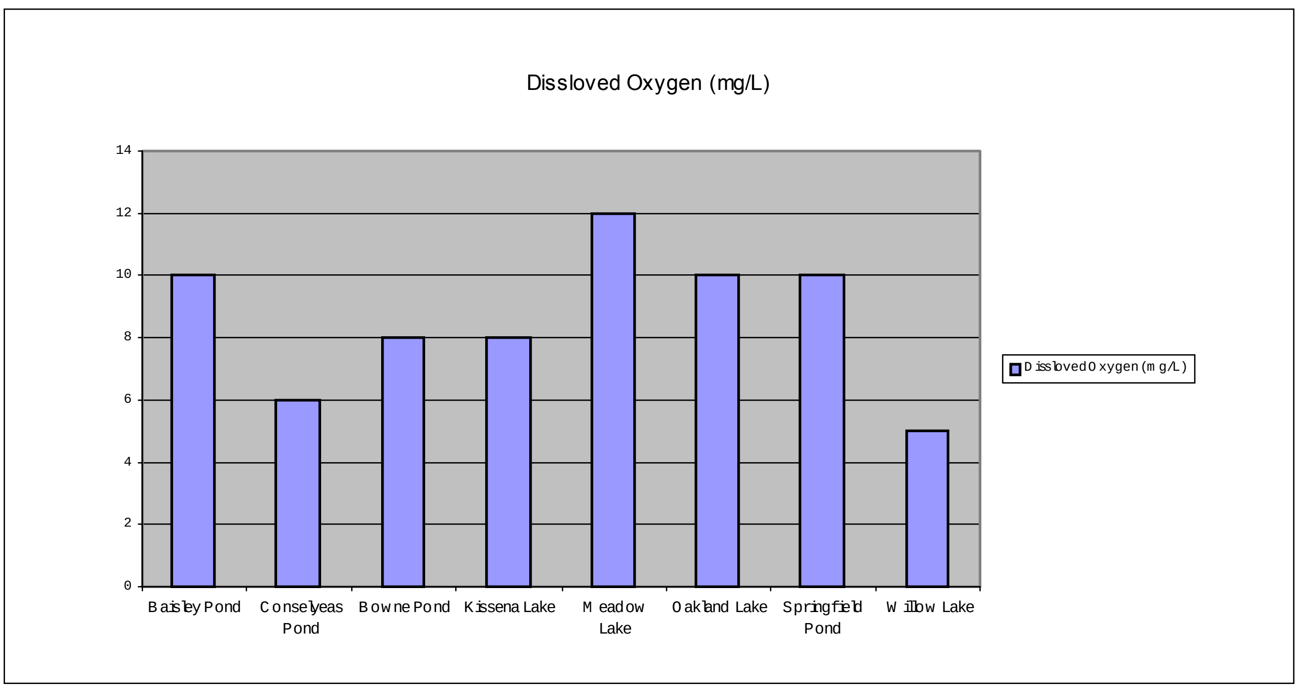

Figure 5. Distribution of dissolved oxygen

CONCLUSIONS

The increasing use of lawn fertilizers is affecting the water quality in this urban hydrologic system. Although many factors can contribute to increasing concentrations of nitrate, ammonia, and phosphate in surface water, this study showed a correlation between the concentrations and the landuse, namely, houses with lawns/garden and parks. More studies need to be done to identify the statistically significant landuse type contributing to a significant change in water quality.

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