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Effects of Dumping Pig Manure into a Lake –The Simpsons Movie

Sonal A. Chagan

The Centre for Interdisciplinary Science, University of Leicester

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Abstract

This paper examines the environmental effects of disposing a silo of pig manure into a body of water the size of a lake. It was calculated that the concentration of manure once dispersed in the lake would be 1.3 g m^{-3} . From the qualitative research it was found that eutrophication would occur and lead to effects that would cause damage to the organisms of the lake. Observable changes such as colour change of the water would also take longer to occur than suggested in the movie. This also applies to the potential genetic effects which would only affect aquatic organisms such as fish, and would take at least 1 month to become observable.

Introduction

In The Simpson Movie, the entire town of Springfield is quarantined by a giant dome due to Homer disposing of a silo full of pig manure from his pet pig 'Spider Pig' into Lake Springfield [1]. Once the silo is dumped, Lake Springfield turns from crystal blue to black and a squirrel enters the lake and re-emerges with 12 eyes [1]. Although very humorous, this dramatic effect is not realistic in determining the actual environmental effects of unloading a large amount of animal manure into a body of water the size of a lake. In this paper, the realistic effects of this event are investigated.

Chemical Content of Pig Manure

Animal manure is a natural organic (carbon-containing) fertiliser that is used to increase crop growth due to its high nutrient content [2]. The specific nutrients present in pig manure are mainly organic nitrogen, potassium (in the form K_2O) and phosphates (in the form P_2O_5) [3].

Both phosphorous and nitrogen are used by plants to produce proteins and nucleic acids essential for plant growth. It is these same properties that make N and P harmful in an aquatic environment when present in too high an amount. Phosphorous in particular has been stated as the limiting factor for the growth of plants in freshwater lakes [4].

Concentration of manure once dispersed in a Lake

A lake is a body of standing water where light does not penetrate all the way to the bottom of the water

and has a uniform temperature [5]. As Lake Springfield is a medium sized US lake [1], the surface area and volume of the lake was based specifically on Lake Nichol in Alaska. The estimated surface area of the lake is $733,000 \text{ m}^2$ and the volume is $1,823,000 \text{ m}^3$ [6].

If we model the long, thin silo of pig manure seen in the movie as a cylinder and assume the height is 3 m and radius is 0.5 m, then the volume of the silo will be 2.36 m^3 (3 s.f.). Therefore the ratio of silo: lake volume is 1 : 773705 (rounded to nearest whole number). As a volume of 0.0351 m^3 (3 s.f.) of manure produced by pigs in a 'Farrow-to-Finish' farm corresponds to 35000 g (2 s.f.) of manure [3], the mass of manure in the silo will be 2300000 g (2 s.f.). Thus the concentration of the pig manure once dispersed in the lake will be 1.3 g m^{-3} (2 sf). This is a relatively small concentration, which is what we would expect for the silo to lake volume ratio.

Process of Eutrophication

If we assume that Lake Springfield is a freshwater lake and that the unloaded pig manure diffuses across the entire lake over a timescale of one week, the release of the nutrients in the manure would lead to the process of eutrophication [7]. Eutrophication is the enrichment of surface waters with plant nutrients [7]. In the initial part of this process, the excess amount of phosphorous and nitrogen present in the lake would cause the increased growth of algae.

It is assumed that the majority of algae in the lake are cyanobacteria, an organism that utilises sunlight for photosynthesis by splitting water into oxygen, electrons and photons [8]. This increase in the growth and biomass of algae-heavy blooms would block sunlight from reaching the plants that grow beneath the surface of the water [7].

Due to the lack of sunlight, plants beneath the surface of the lake would not be able to photosynthesise and produce the organic compounds they need to function. As a result the plants would die and decomposers would feed on the dead plant matter. This leads to an increase in the number of bacterial decomposers present, which subsequently use up a larger amount of the dissolved oxygen present in the lake when they aerobically respire. The algae present in the lake also eventually die, which again depletes the lake of oxygen. The hypoxia (lack of oxygen) of the waters leads to the death of larger aquatic organisms such as fish which cannot respire without oxygen [9]. This ultimately leads to 'dead zones' whereby the majority of organisms in the lake cannot survive in the conditions of the lake [10].

Colour Change Observed in Lake

Referring back to the movie, Lake Springfield undergoes a colour change to black as soon as the pig manure is added (see figure 1).



Figure 1) Colour change of lake that occurs after Homer dumps manure into Lake Springfield [1].

Realistically, the eutrophication of a lake causes it to become cloudy and take on either a green, brown, red or yellow colour change. The colour observed depends on the type of algal bloom that occurs in the surface water (see figure 2). As we have assumed that the lake consists primarily of cyanobacteria, the lake would become a green-blue colour [11].

In terms of timescales, the initial process of eutrophication leading to a colour change would take weeks, if not months to complete. This contrasts with the immediate negative environmental effects that seem to occur in The Simpsons Movie.

Genetic Defects due to Lake Pollution

The movie also makes reference to the biological effects such as potential mutations that can occur in organisms due to a polluted lake (displayed in the form of a squirrel entering Lake Springfield and re-emerging with multiple eyes).



Figure 2) Colour change observed in lake due to an increase in cyanobacteria (blue-green algae) [12].

Although it is very unlikely that a genetic change of this extent would occur to a non-aquatic adult organism, if eutrophication is untreated for a long enough period of time, the hypoxic waters of the lake can cause genetic defects in the reproduction of fish in the lakes. These effects include a decrease in the size of fish reproductive organs, fewer eggs being produced and a lack of spawning [13]. The length of time it takes for these effects to be observed is one month (in laboratory conditions) [13].

Conclusion

In this paper the environmental effects of disposing a silo of pig manure into a lake have been investigated. In comparison to The Simpsons Movie, dumping a high amount of fertiliser into a lake would have adverse effects on the quality of water and fauna organisms. The concentration of manure once dispersed in the lake is estimated to be relatively small; 1.3 g/m^3 . In contrast to the movie, it would take much longer a colour change to emerge. In terms of the biological effects of lake pollution on organisms, genetic effects would only be observed in aquatic organisms that live in the lake such as fish and this would take ~ 1 month to occur.

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