FRESHWATER SCIENCE

DO MUCK-DIGESTING PELLETS WORK?

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One of the largest issues that lakefront homeowners currently face is the accumulation of muck (organic matter) on the lake bottom. Most of this muck accrual derives from decomposing aquatic vegetation and algae. This organic material can result in a number of ecological and aesthetic issues, including impeded navigation due to decreased water depth, undesirable odors, and release of nutrients to the water column, thereby stimulating algal blooms.

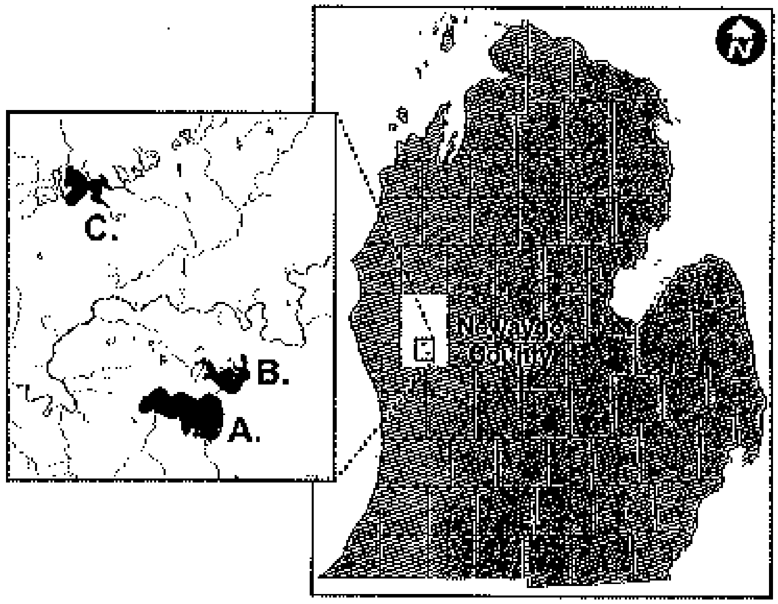

FIGURE 1. LOCATION OF NEWAYGO COUNTY WITHIN THE LOWER PENINSULA OF MICHIGAN. BLOW UP SHOWS LOCATION OF LAKES FROM WHERE SEDIMENT WAS SAMPLED: A. HESS LAKE; B. BROOKS LAKE; C. PICKEREL LAKE.

MUCK DIGESTION PELLETS

As a consequence, removal of muck is a common request from lakefront homeowners. However, management options such as dredging can be very expensive (Cooke et al. 2016, Lürling et al. 2020), assuming approval can even be obtained. A much less expensive option is commercially available pellets that "eat" muck. These products consist of bacteria and enzymes that are advertised to reduce muck in your lake. Of course, the organic matter (OM) cannot truly disappear, but it can be converted from a solid form to a gaseous form. A mechanistic explanation by which these pellets digest and reduce OM is not provided by manufacturers, but it can be assumed that enzymatic activity would be responsible for this process whereby the solid mass is broken down to carbon-containing gases, such as carbon dioxide and/or methane (e.g., Bastviken et al. 2003).

The effectiveness of these pellets has not been validated in the peer-reviewed scientific literature, although two non-peer-reviewed studies have been conducted, one in Florida (Slagle and Allen 2016) and the other in Connecticut (Ken Wagner, unpubl. data). In both cases, there was no conclusive effect of the pellet treatment on muck removal, but limited sampling and environmental variation precluded definitive conclusions.

Given the prevalence of these products in the marketplace and the lack of peer-reviewed studies to assess their effectiveness, the Newaygo County (MI) Drain Commissioner's Office, in concert with Michigan State University Extension, contracted with the Annis Water Resources Institute at Grand Valley State University to conduct a study to examine how well these pellets work.

EXPERIMENTAL DESIGN

In August of 2020 we sampled the sediment and water from three lakes in Newaygo County (Fig. 1) and brought them back to the Annis Water Resources Institute for processing and experimental set-up. Sampling sites were relatively shallow (≤ 2m), well oxygenated, and meso- to eutrophic

FIGURE 2. TOP PANEL: SEDIMENT TUBE SET-UP IN GROWTH CHAMBER WITH GAS LINES THROUGH EACH KNOCK-OUT CAP IN PLACE; TUBE DIAMETER - 7.5 CM. BOTTOM PANEL: REPLICATE BINS FOR ONE LAKE-EITHER PELLET OR CONTROL. ALL BINS REMAINED OPEN TO THE AIR FOR THE WHOLE DURATION OF THE EXPERIMENT. BIN INTERIOR DIMENSIONS AT BOTTOM = 0.40 M X 0.29 M.

TABLE 1. LAKE PHYSICAL WATER QUALITY PARAMETERS MEASURED ON 18 AUGUST 2020 FROM A SINGLE SITE PER LAKE.

Lake	Secchi disk depth (m)	Site depth (m)	DO (mg/L)	pH	Temp. (°C)	Sp. Cond. (µS/cm)	TP (µg/L)	SRP (µg/L)	Mean sediment % OM
Hess	0.7	1.5	9.03	8.82	24.66	296	42	<5	48.8
Brooks	0.8	2.0	9.29	8.76	26.29	308	24	<5	17.3
Pickerel	1.1	1.4	9.15	8.58	26.33	319	9	<5	17.6

DO - DISSOLVED OXYGEN; TEMP - TEMPERATURE; SPCOND = SPECIFIC CONDUCTANCE; TP - TOTAL PHOSPHORUS; SRP - SOLUBLE REACTIVE PHOSPHORUS; OM - ORGANIC MATTER.

but with soluble reactive phosphorus concentrations below detection (Table 1). Sediments were collected with a Ponar sampler, brought back to the lab, and incubated for eight weeks in enclosed tubes under different environmental conditions inside a growth chamber, as well as in larger bins contained in a tank room at room temperature (Fig. 2).

The sediment tubes used for this experiment were clear PVC (25 cm height x 7.5 cm diameter) with punch-out caps that allowed for minimal free exchange of gases. We added 200 mL of sediment and 650 mL of water to each tube. Tubes were maintained at either the ambient temperature at the time of collection (25.8 °C; n=8 tubes) or ambient +3 °C (28.8 °C; n=8 tubes). We report only ambient results here as temperature had no statistically significant effect. Both growth chambers were set with a 13.75:10.25 light:dark cycle corresponding with western Michigan daylight in August, and had a similar average PAR of 40 µmol/m²/s, mimicking the light levels at the sediment surface. We also manipulated dissolved oxygen concentrations (anoxic or oxic but report only oxic results here; dissolved oxygen had no statistically significant effect). Tubes were divided evenly into a group receiving muck-digesting pellets (pellet) and a non-pelleted (control) group, with n=2 tube replicates for each of the three lakes.

Generic 45.4 L storage bins were used to test the pellet muck digestion on sediment surface areas and volumes that were larger than the tubes. We used six bins per lake: three with pellet addition and three control bins (no pellet). We added ~1420 mL of sediment to each bin (depth: 2.54 cm, surface area: 0.1204 m²) and then added 9.5 L of unfiltered lake water to each bin. Bins were maintained at room temperature (~17 °C) for the first week of the study and then ~19-22 °C for the rest of the duration; however, there was one two-day temperature drop to room temperature at the end of October. Light was not regulated for the bins and they were kept under dark conditions for the majority of the study.

After the initial sediment and water set-up, all tubes and bins were allowed to settle overnight prior to pellet additions. Supplemental water collected from each lake was sequentially filtered through 1.0 µm and 0.2 µm filters, and then stored in buckets at the same temperature as the bins mentioned above until needed for water replacement in the tubes, which occured at four weeks, or for addition to the bins to account for evaporative loss.

The Mukk Busster pellets used for this experiment were manufactured by AirMax, Inc. and donated by Cygnet Enterprises, Inc. (Flint, Michigan) without any restrictions. This type of pellet has been used in regions of all three lakes in the past. The surface area per pellet recommended by the pellet company (one pellet per 0.46 m² of lake surface) was much larger than the surface area of our tubes or bins. The smallest practical and divisible size using a pill cutter for our study was ¼ of a pellet. One-quarter pellet was added to each tube and seven whole pellets were added to each bin, which equated to generally similar degrees of over-application in the tubes and bins (26× and 28×, respectively).

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Water quality was measured in the tubes at four and eight weeks, and in the bins after twelve weeks. Sediment was sampled at the end of each experiment for organic matter (Steinman et al. 2017) and bacterial community composition after DNA extraction and amplification using PCR for the 16S rRNA v4 region with the 515F/806R primer set (Caporaso et al. 2012). Amplicons were sequenced using a 2 × 250 bp format, along with a 15% spike-in of Phi-X, on the Illumina MiSeq System.

Treatment	Hess	Brooks	Pickerel
	Tubes		
Pellets	+2.01 ± 0.06	+8.12 ± 0.59	-2.68 ± 0.02
Control	+1.32 ± 0.32	+7.85 ± 0.17	-2.24 ± 0.29
	Bins		
Pellets	+1.38 ± 0.76	+4.90 ± 0.93	-2.18 ± 0.33
Control	-1.94 ± 2.43	+3.90 ± 0.19	-1.08 ± 1.15

TABLE 2. MEAN (+/- SD) CHANGE IN % SEDIMENT ORGANIC MATTER (OM). TUBE DATA ARE FOR AMBIENT TEMPERATURE, OXIC CONDITIONS, AND AFTER 8 WEEKS (N = 2). "+" INDICATES AN INCREASE IN OM; "-" INDICATES A DECREASE IN OM. THERE WERE NO STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN THE PELLET VERSUS CONTROL TREATMENTS FOR ANY LAKE OR INCUBATION VESSEL.

RESULTS

Hess Lake had significantly higher sediment %OM than both Brooks and Pickerel Lakes ($p < 0.0001$), while Brooks and Pickerel Lake's initial sediment %OM was not significantly different from each other ($p = 0.456$; Table 1). However, because we sampled only one region per lake, we cannot account for spatial variability within lakes.

Regardless of the incubation conditions, we found no statistically significant differences in the change in percent organic matter between the pelleted and control treatments (Table 2), although OM increases or decreases differed among lakes. Unexpectedly, there was a slight increase in Hess Lake %OM and a distinct increase in Brooks Lake %OM. We have no definitive explanation for the increase in OM in Brooks Lake, but because it occurred in both types of experimental containers, we believe the increase was not an artifact. We measured a small decline in Pickerel Lake %OM.

Bacterial community composition had little explanatory power for changes in OM and water quality; native dominant genera differed only among lakes, not among the pellet versus control treatments. The pellet treatment did significantly increase chloride (Cl-) concentrations (measured only in the bins), with the pellet versus control mean (±SD) Cl- concentrations in Hess, Brooks, and Pickerel Lakes as follows: 929 ± 91 vs. 29 ± 3; 885 ± 23 vs. 27 ± 2; and 911 ± 187 vs. 30 ± 3, respectively. The mean chloride concentrations in bins with pellets exceeded the 230 mg/L chronic toxicity threshold for freshwater and also exceeded the 860 mg/L acute toxicity threshold (NaCl; USEPA 1988). This is likely due to the overdosing used in our treatments. Dosing in lakes at the recommended levels should not result in chloride toxicity; following manufacturer guidelines is always recommended.

CONCLUSIONS

The results from this study indicate that the application of Mukk Busster pellets does not result in a significant reduction of sediment OM from three test lakes. Regardless of environmental condition or sediment volume, there were no statistically significant differences in changes in %OM between treatments with pellets and those without pellets. Our results, while clear, are based on controlled lab studies, and we used doses that were higher than manufacturer recommendations. We contacted the manufacturer who informed us that high dosing can negatively affect the bacteria strains in the pellets due to the production of excess Cl-. While our dosing levels did result in significant levels of Cl-, our analyses revealed no significant differences in bacterial community structure between control and pelleted treatments. Hence, the absence of a pellet effect on muck digestion could not be attributed to purported changes in Cl- concentration and its associated change in the existing bacterial community. Thus, we conclude that these pellets are not an effective treatment to reduce sediment OM in these lakes. We recommend that future studies test pellets in natural lakes, using replicated enclosures of varying diameters. This will allow dosages closer to recommended levels and also isolate the sediment and water column from the surrounding water and sediment.