Microbial Quality Analysis of Water Runoff For Biosolid-Applied Fields in Southern Arizona

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Abstract

Biosolids, solid waste byproducts resulting from wastewater treatment, pose both a challenge for disposal for wastewater treatment facilities, and a great opportunity for farmers to use a new source of fertilizer. Very little research has been completed on the effect of biosolid application on a farm’s water quality. Using indicator organisms such as *E. coli* and total coliform counts, we determined that runoff from biosolid-applied fields exhibited upwards of five to ten times the microbial activity of runoff from chemically fertilized fields. This marked increase is of little concern, however, since the runoff is adequately diluted upon return to the irrigation canal.

Introduction

It was estimated in 2001 that 7.0 million metric tons of biosolids were produced by wastewater treatment facilities every year, and that 54% of these solids are applied to farmland in the place of fertilizer (Epstein, 2003). Based on recent trends, both of these values will increase in the near future. The farmer and wastewater treatment plant manager have a mutually beneficial relationship in which the farmer receives fertilizer filled with nitrogen and phosphorous, and the treatment plant has an effective means of waste disposal.

The class B biosolids generated by the Ina and Roger Road wastewater treatment facilities also contain a high amount of pathogens. There has been public concern regarding the current agricultural application process, specifically the possibility of contamination of other fields and water sources through tailwater runoff, a subject which is little researched.

Tailwater is the runoff generated in the normal irrigation of furrows. Although farmers attempt to minimize tailwater and improve irrigation efficiency, tailwater is usually necessary to insure that crops at the end of the row get sufficient amounts of water. After the tailwater runs off the field, it may be reused via diversion to the irrigation canal (see figures 1 and 2).
Figure 1. Diagram of a typical biosolid-applied field in Marana

Figure 2. Irrigation of a Durum Wheat field in Marana
If the tailwater comes from a field which had recently been applied with biosolids, the runoff may contain significant amounts of biological contaminants, which would pose a risk for food-borne illness should the reused irrigation water be applied to a crop which comes in contact with the ground, such as cantaloupe or lettuce.

This study is an evaluation the current scenario in Marana, using fields containing Milo, a sorghum-based plant, and Durum Wheat, both used for animal feed. The farms in this study use 6% liquefied biosolids applied via disc injection. Tailwater runoff, irrigation inflow, and a control site will be assayed for microorganisms in order to:

1) determine if runoff from biosolid-applied fields presents a danger for bacterial contamination of other areas,
2) present a model for how pathogens die off in these fields, and
3) discuss best management practices to avoid microbial food contamination.

**Methodology**

Water samples were collected in sterile one-liter containers and were assayed for coliforms, *E. coli*, and presence/absence of salmonella. Surface soil samples were collected using a sterile spatula, and placed into a Ziploc bag. All samples were assayed within 24 hours of collection.

*E. coli* and coliform counts were obtained using the Colilert test (APHA, 1998). Water samples were assayed according to test directions. Soil samples were diluted 10:1 by placing 5g of soil into 45mL of peptone-water (1g/L), and stirring for 20 minutes. 10mL of this solution was added to 90mL of sterile water to obtain a total 100x dilution as described by Zuberer (1994).

One liter of water (usually in 250 mL intervals) was tested for salmonella via membrane filtration using a modified USEPA method 1682. The filter paper was placed into 10mL of dulcitol selenide broth. For soil samples, 5g of soil was placed directly into the selenide broth. The broth was incubated at 38°C for 24 hours. The turbid broth was then spread-plate onto XLD and Hecktoen media using a loop, and allowed to incubate at 38°C for 24 hours. Positive colonies were spread onto TSA media, and tested using indole and spot oxidase tests. The colonies were then further tested using triple-sugar iron (TSI) and Lysine Iron Agar (LIA) slants.

**Results and Discussion**

The data given in Table 1 is a compilation of *E. coli* and total coliform counts from water gathered at the end of the furrow. This is assumed to be equivalent to what the runoff would be if it returned to the irrigation channel. Salmonella samples were all negative. Fields were sampled on five different dates.
Table 1: Comparison of *E. coli* concentrations for biosolid-applied vs. chemically fertilized fields

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<tbody>
<tr>
<td>Irrigation water</td>
<td>125.9</td>
<td>1</td>
<td>13.4</td>
<td>3.1</td>
<td>0</td>
</tr>
<tr>
<td>Other tailwater, from fields without biosolids</td>
<td>228.2</td>
<td>n/a</td>
<td>203.5</td>
<td>29.5</td>
<td>n/a</td>
</tr>
<tr>
<td>Tailwater sample (slow moving, clear)</td>
<td>727.0</td>
<td>68.2</td>
<td>73.0</td>
<td>187.2</td>
<td>1413.0</td>
</tr>
</tbody>
</table>

Both the *E. coli* and total coliform counts varied greatly from day to day due to temperature variation. In general, tailwater from chemically fertilized farms contain two to ten times the indicator organisms of irrigation water, and tailwater from biosolid-applied fields have around five times the amount of indicator organisms as chemically fertilized fields. Figure 3 (samples taken on 3/23) best compares the indicator organisms for biosolid-applied versus chemically fertilized fields:

![Figure 3: Indicator organism assays for three water types](image)

Figure 3: Indicator organism assays for three water types
Figure 4: Organism counts for a biosolid-applied field

It appears that both coliforms and *E. coli* rise at the same rate for the two different field types. Figure 4 (samples taken on 3/27) gives insight into how these organisms are accumulated in the irrigation water:

Coliforms remain fairly constant throughout the field, while *E. coli* accumulates. The organism counts for irrigation water were unusually low, and no other runoff was available for comparison of the data set.

Even though there is a rise in pathogenic indicator organisms for the biosolid-applied fields, there are three major reasons why this is not of significant concern:

1) very few fields have return flows,
2) the current crops irrigated in Marana (e.g. Durham Wheat, milo, cotton) are not used for direct human consumption, and
3) the irrigation canal to which the tailwater flows is very large, and should sufficiently dilute contaminants.

Water flow rates for an irrigation canal and the associated return canal were measured using a floater and a stopwatch during the sampling on 3/27. Again, no water from the field returned to the return canal. Assuming uniform flow, the irrigation canal had a flow of 4.9 cfs, and the return canal had a discharge of 19.5 cfs, which would produce a minimum dilution factor of approximately four. Actual dilution values would be much larger since the majority of the irrigation water is absorbed in the furrow. Nevertheless, this data suggests that tailwater fields fertilized with class B Biosolids in Marana are not of a significant health risk threat should that water irrigate other fields.
Conclusion

It was determined that only a small fraction of the biosolid-applied fields have return flows. In fact, no return flows of biosolid-applied fields were directly observed in during the sampling period. Most fields have the majority of their land area bordered up, with only a fraction of each field producing a return flow. This type of irrigation is a good measure to prevent the spread of microorganisms. Many fields are surrounded completely by a border, not producing any return flows at all, while others deliver their runoff into a settling basin.

References:


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