3.5. INTERPRETING SOIL QUALITY: SPIDER RADAR GRAPHS FOR MULTIPLE INDICATORS

As discussed in chapter 2, spider/radar graphs give users a composite environmental quality evaluation by showing how well multiple indices conform to the limits of each indicator's sustainable range (as compared to scanning through many control charts). Indices (purple dots) that lie within their target range (zone between red lines) show soil indictors operating in a sustainable mode. Indices lying outside their target range represent an indicator in need of remediation. A high quality ecosystem would show a nearly circular radar image (colored area outline by purple dots) within the sustainable range. Degraded functions lying outside the sustainable range skew the radar image and alert the superintendent or manager to begin remediation.

Data from the first sampling period (pre-application) and the last sampling (October 26th) have been taken from the control charts and converted to spider/radar graphs (Figures 3.27 to 3.46). Biological soil quality indicators were not reported until July so the microbial values have been standardized to 0 for all pre-treatment graphs. In order to standardize all of the soil quality indictors from control charts and graphs to spider/radar graphs discretionary upper and lower threshold limits were chosen for five indicators. The soil indicators that had no previous established limits are; total carbon, total nitrogen, mineralizable nitrogen, mineralizable carbon, and soil respiration. The organization of the spider/radar graphs are presented on the next page.

Soil Quality Index – Spider/radar graphs

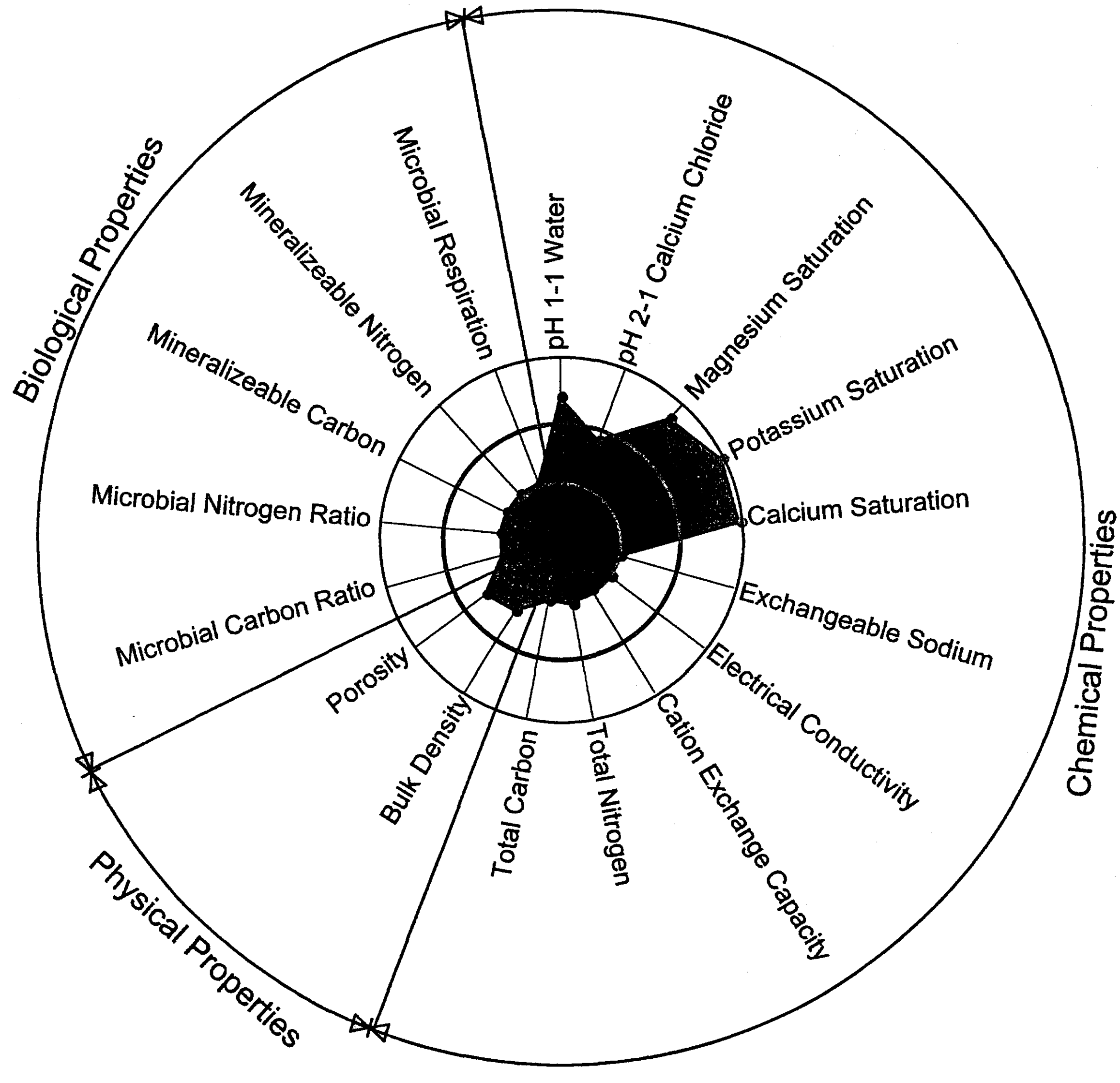

Figure 3.27. Composite soil quality index for seventeen soil quality indicators for untreated green soil before first application date (May 11th, 2000). Standardized values for calcium saturation and potassium saturation are both shown as 2x the upper control value. Actual values are 4.25x and 10.3x the upper control limit for calcium and potassium saturation respectfully.

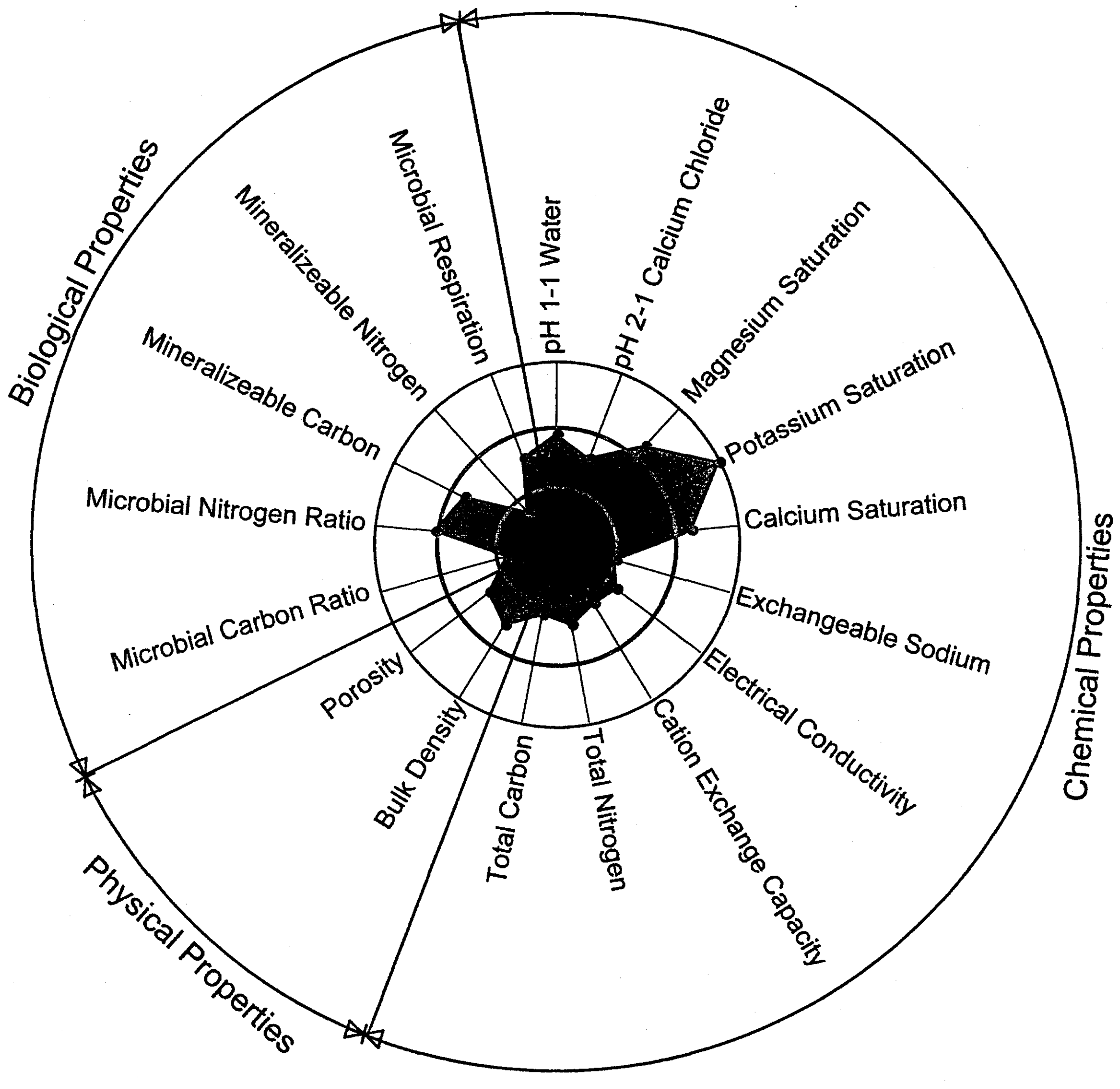

Figure 3.28. Composite soil quality index for seventeen soil quality indicators for untreated green soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for potassium saturation is shown at 2x the upper control limit, while, the actual value is 2.78x the upper control limit.

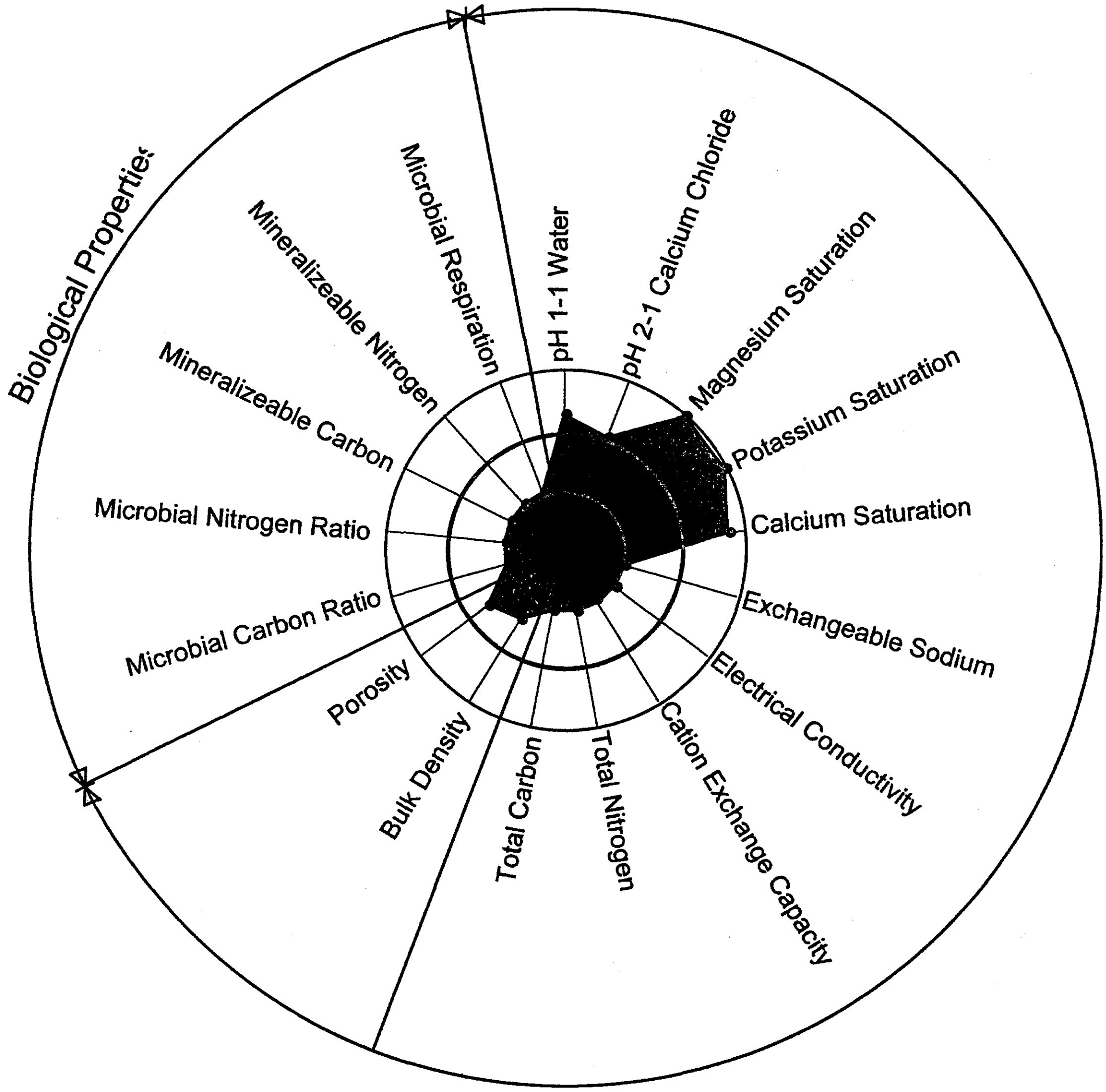

Figure 3.29. Composite soil quality index for seventeen soil quality indicators for swine 1x treated green soil before first application date (May 11th, 2000). Standardized values for magnesium saturation and potassium saturation are both shown as 2x the upper control value. Actual values are 2.5x and 13.2x the upper control limit for magnesium and potassium saturation respectfully.

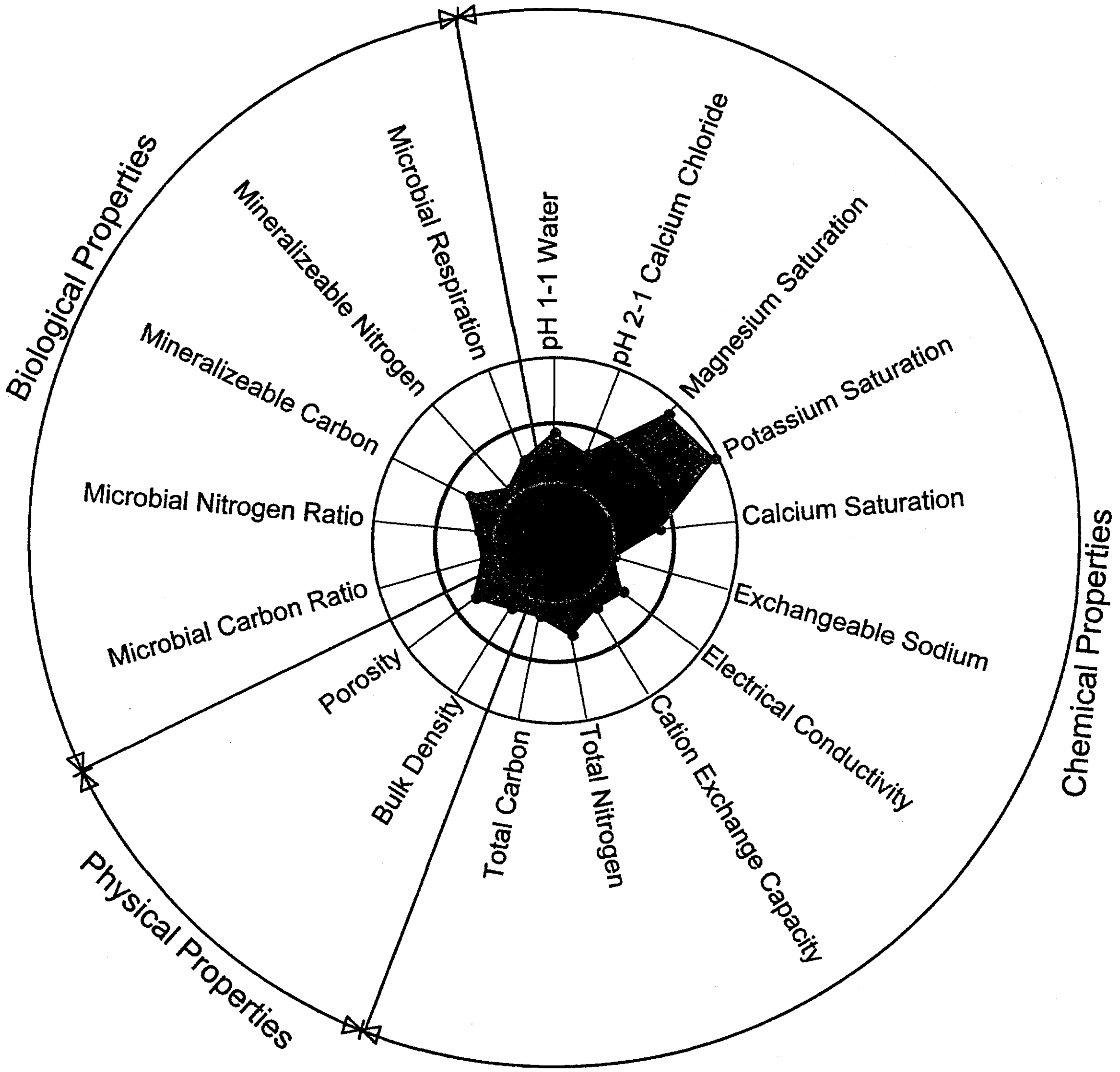

Figure 3.30. Composite soil quality index for seventeen soil quality indicators for swine1x treated green soil 45 days (Oct. 26th, 2000) after last application date.

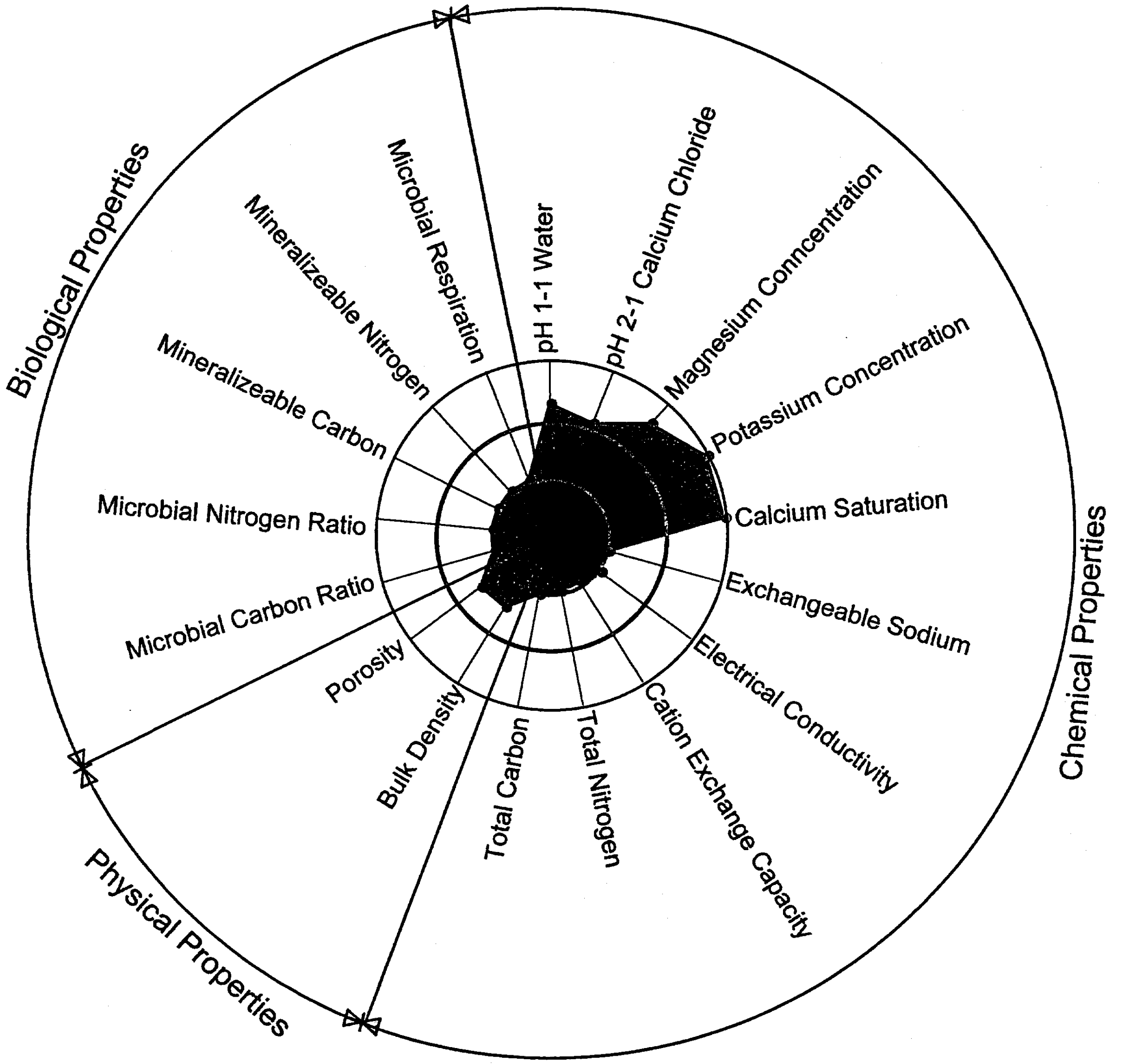

Figure 3.31. Composite soil quality index for seventeen soil quality indicators for swine 2x treated green soil before first application date (May 11th, 2000). Standardized values for calcium saturation and potassium saturation are both shown as 2x the upper control value. Actual values are 4.75x and 7.6x the upper control limit for calcium and potassium saturation respectfully.

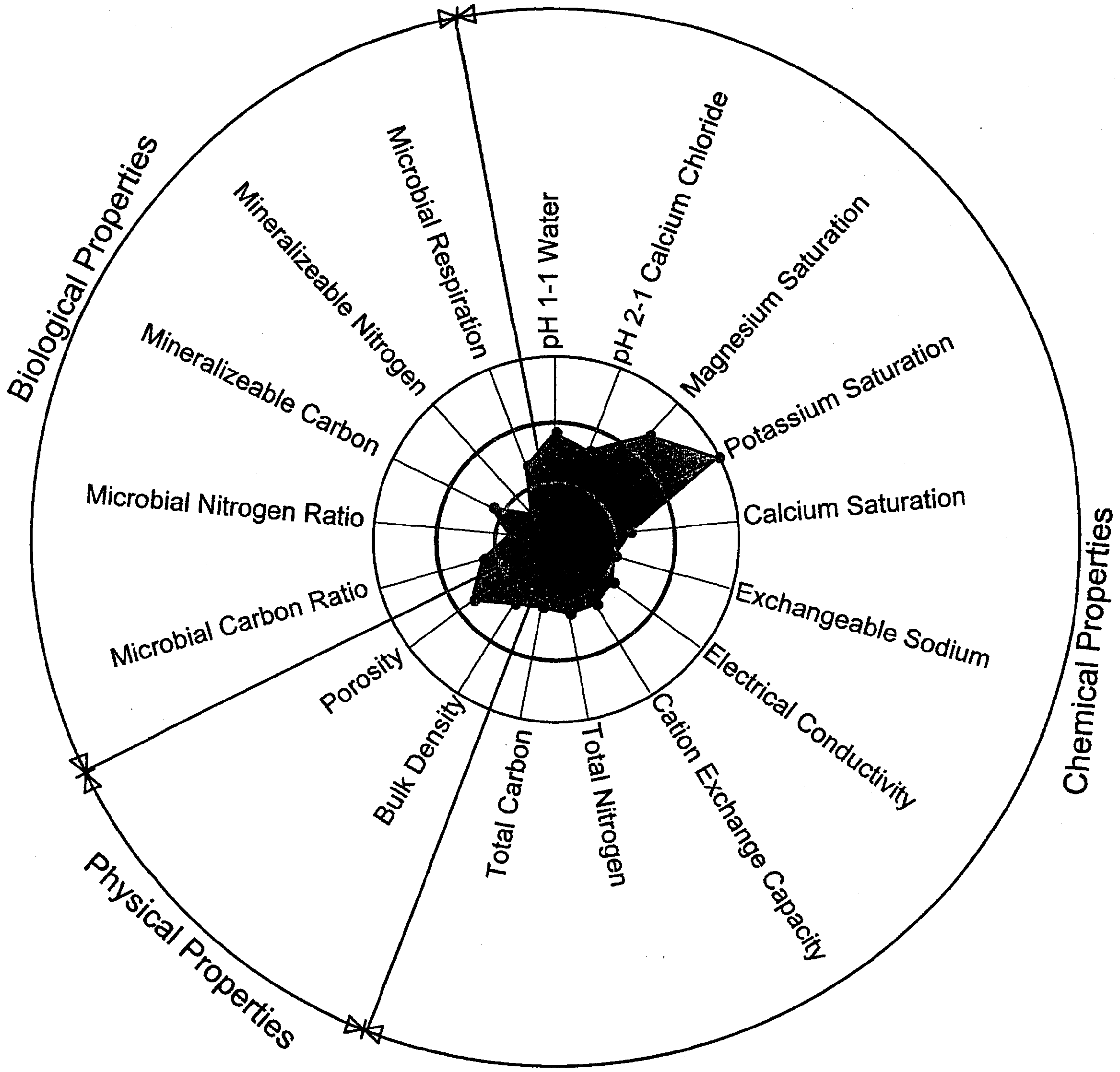

Figure 3.32. Composite soil quality index for seventeen soil quality indicators for swine 2x treated green soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for potassium saturation is shown at 2x the upper control limit, while, the actual value is 2.5x the upper control limit.

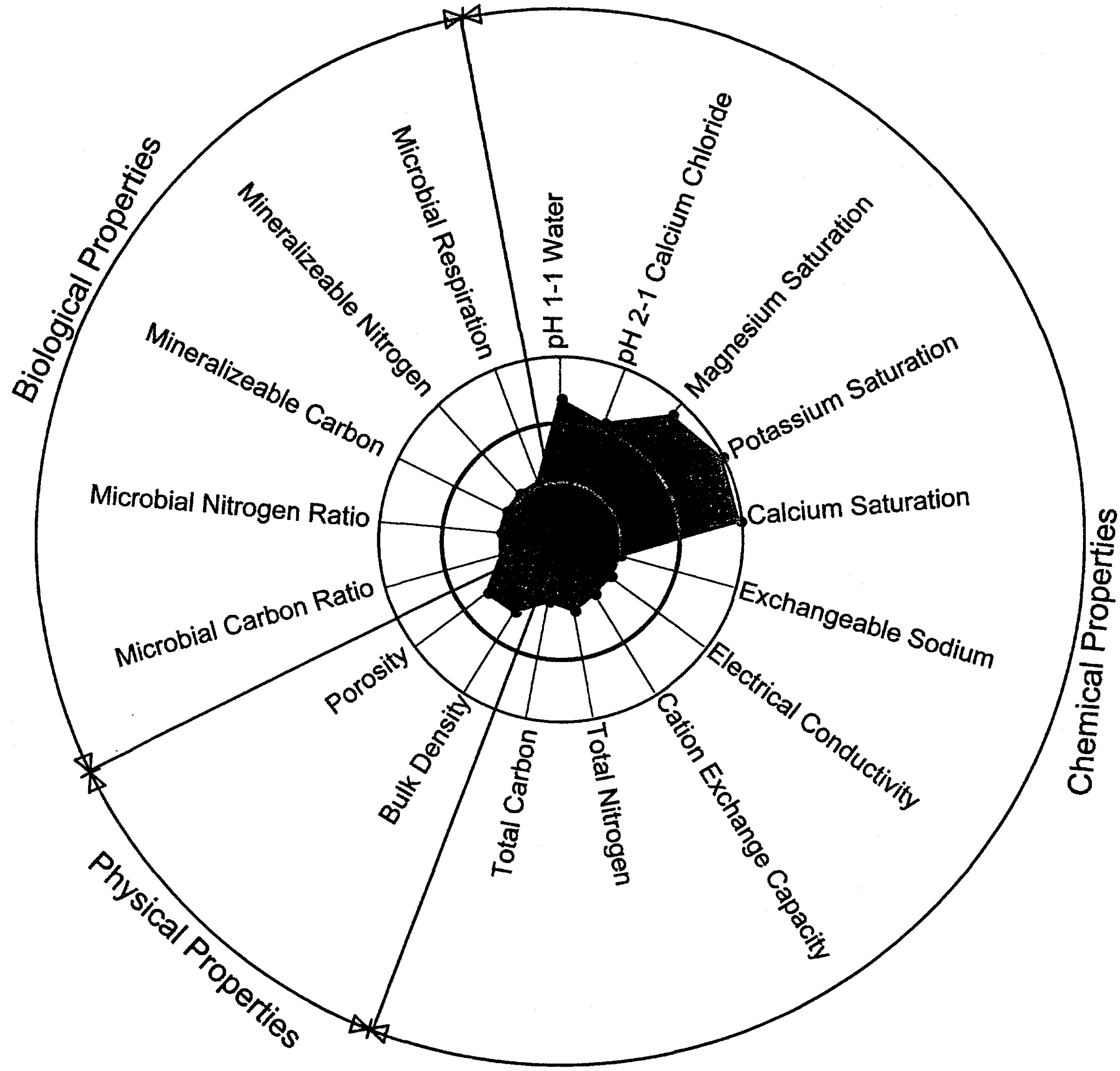

Figure 3.33. Composite soil quality index for seventeen soil quality indicators for dairy 1x treated green soil before first application date (May 11th, 2000). Standardized values for calcium saturation and potassium saturation are both shown as 2x the upper control value. Actual values are 2.75x and 9.9x the upper control limit for calcium and potassium saturation respectfully.

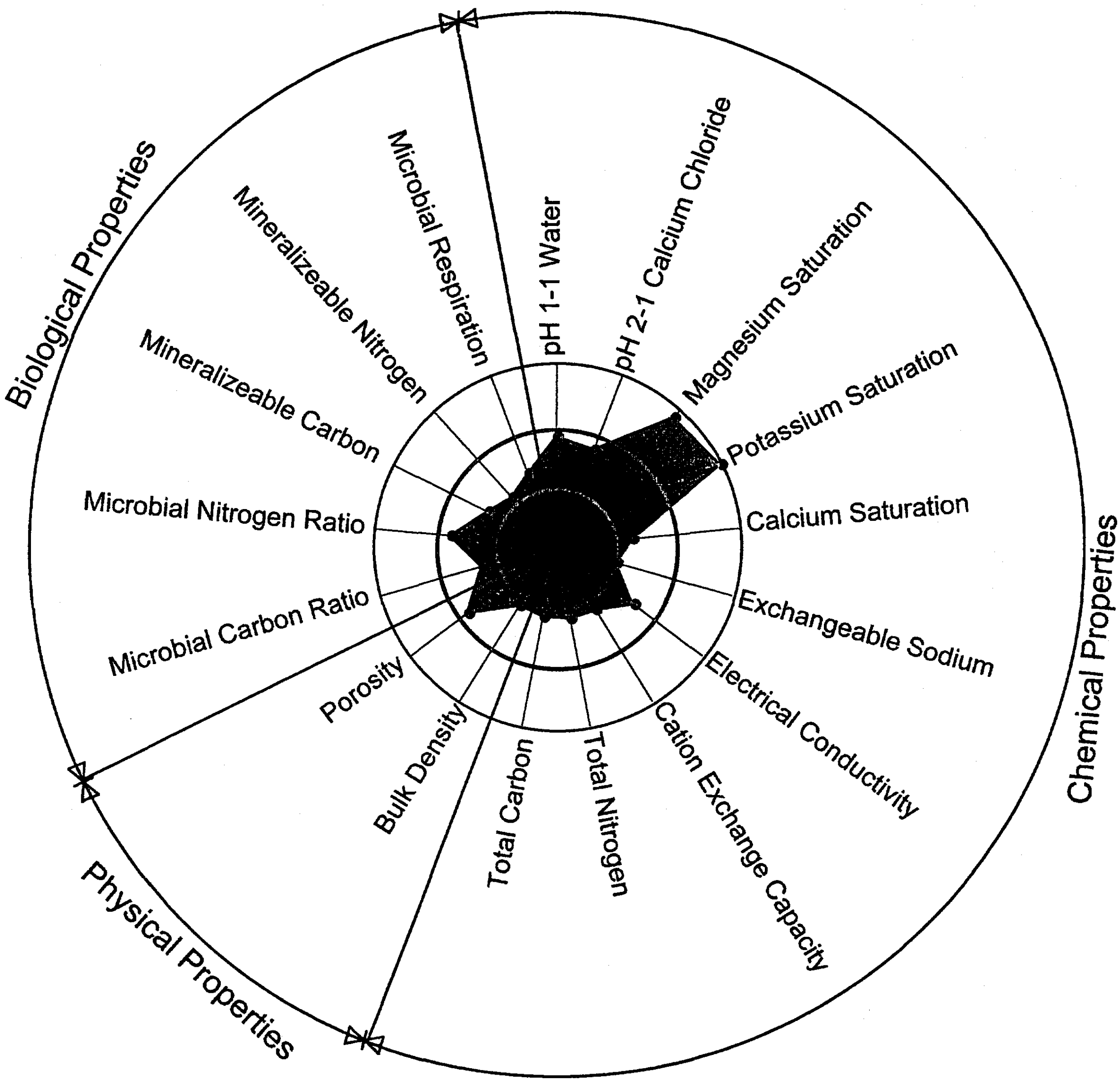

Figure 3.34. Composite soil quality index for seventeen soil quality indicators for dairy 1x treated green soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for potassium saturation is shown at 2x the upper control limit, while, the actual value is 2.2x the upper control limit.

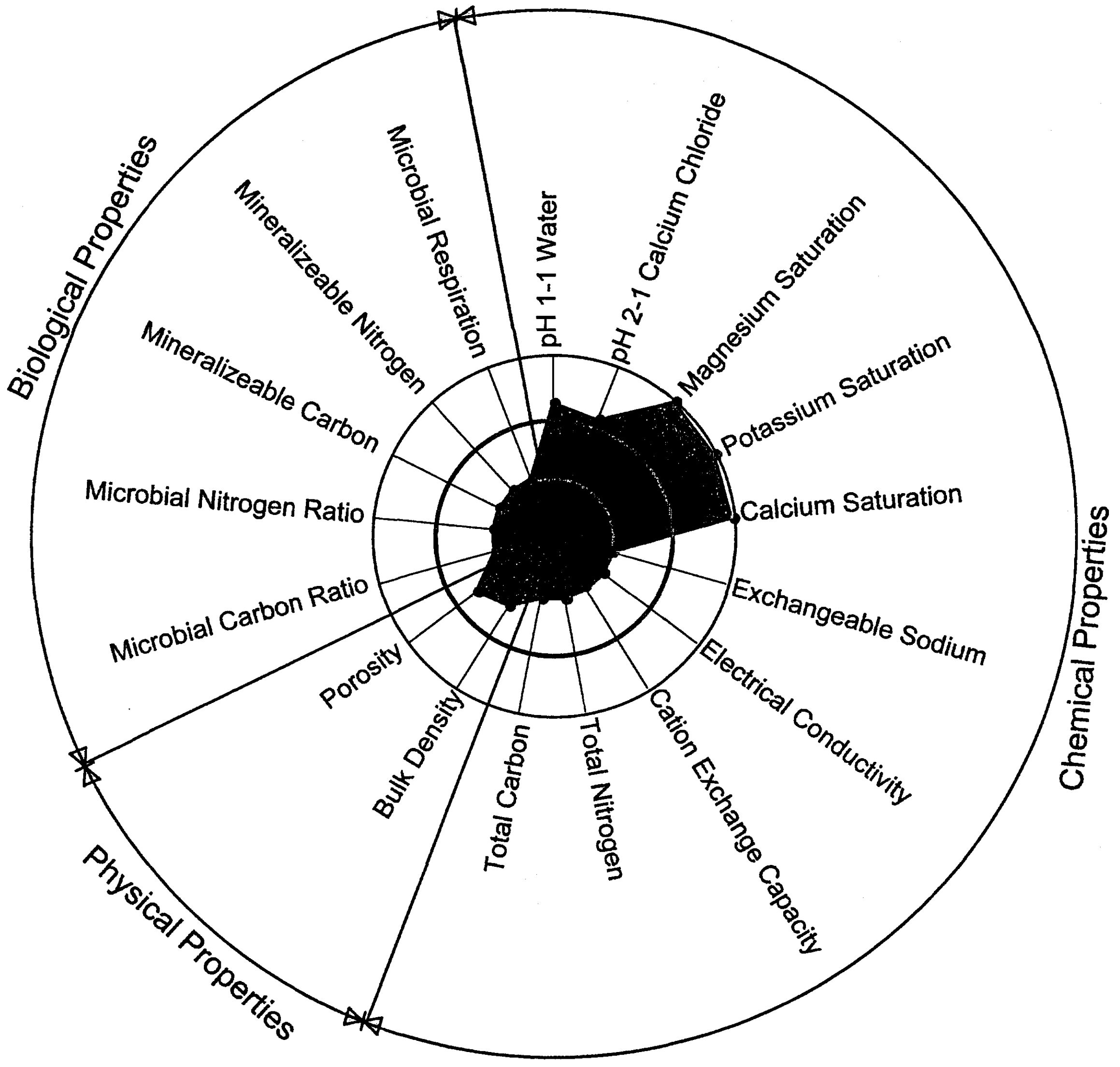

Figure 3.35. Composite soil quality index for seventeen soil quality indicators for dairy 2x treated green soil before first application date (May 11th, 2000). Standardized values for calcium saturation, magnesium saturation, and potassium saturation are all shown as 2x the upper control value. Actual values are 3.75x, 2.7x and 12.6x the upper control limit for calcium, magnesium, and potassium saturation respectfully.

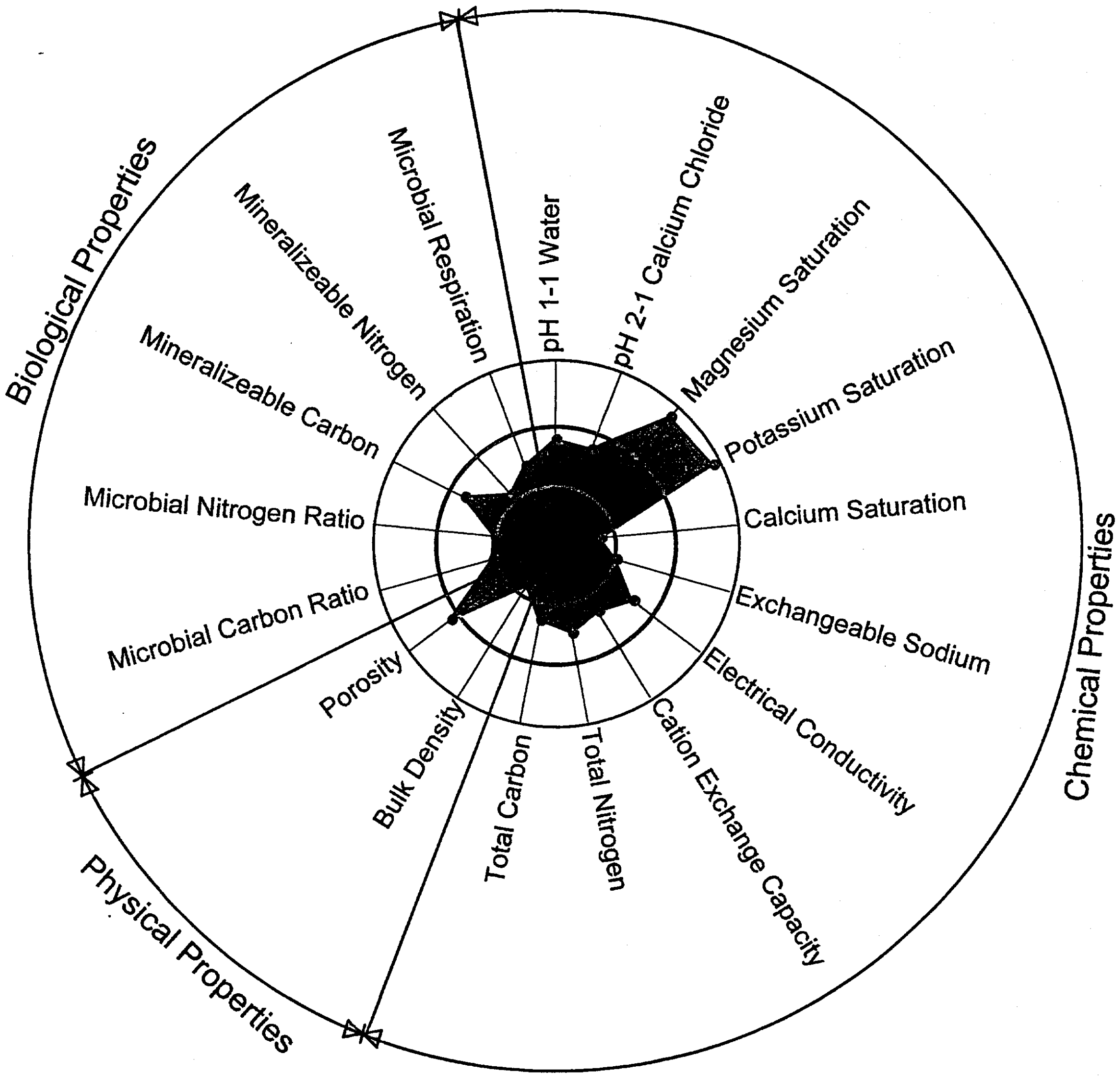

Figure 3.36. Composite soil quality index for seventeen soil quality indicators for dairy 2x treated green soil 45 days (Oct. 26th, 2000) after last application date.

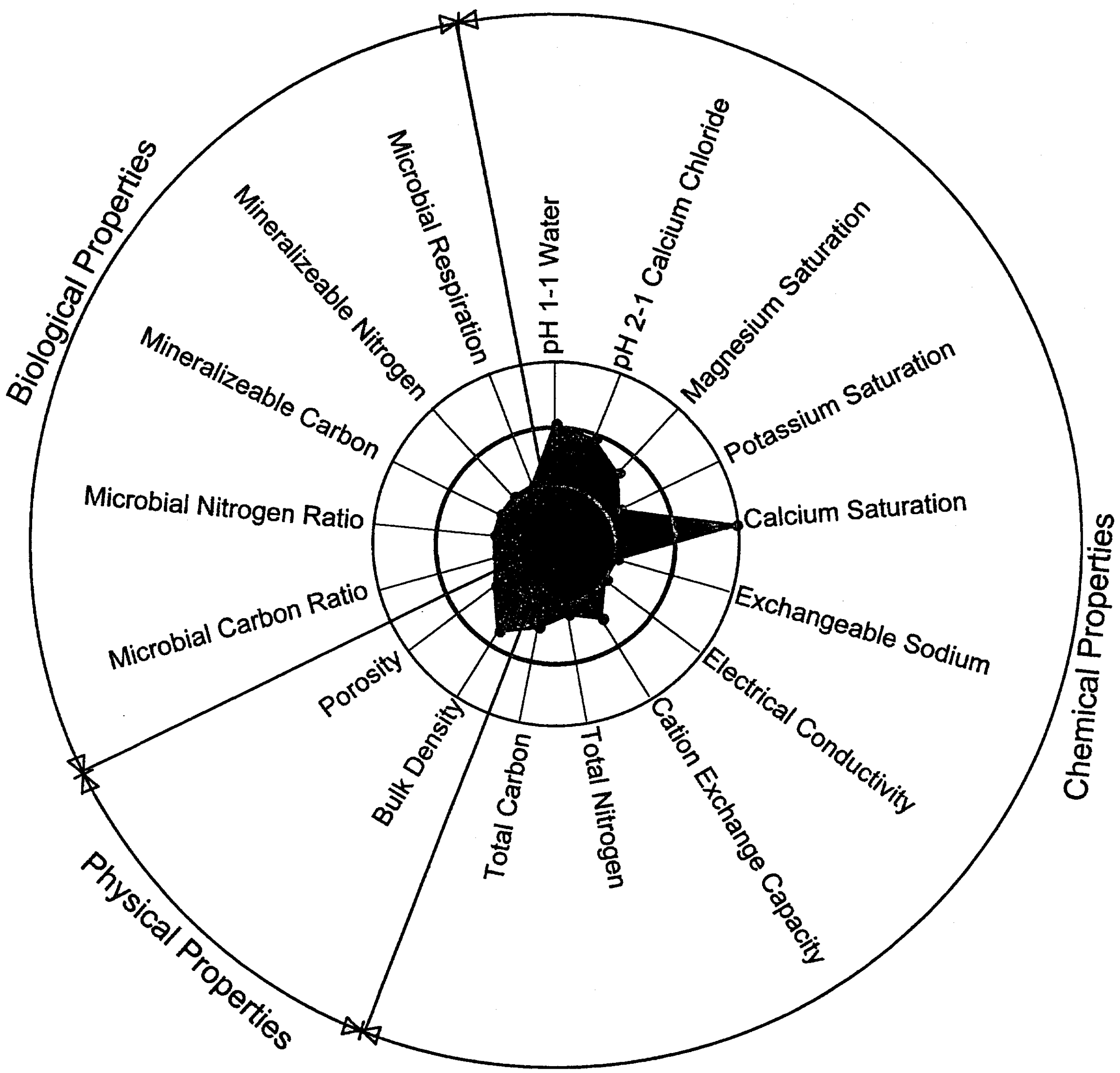

Figure 3.37. Composite soil quality index for seventeen soil quality indicators for untreated tee box soil before the first application date (May 11th, 2000). The standardized value for calcium saturation is shown at 2x the upper control value, while, the actual value is 4.25x the upper control limit.

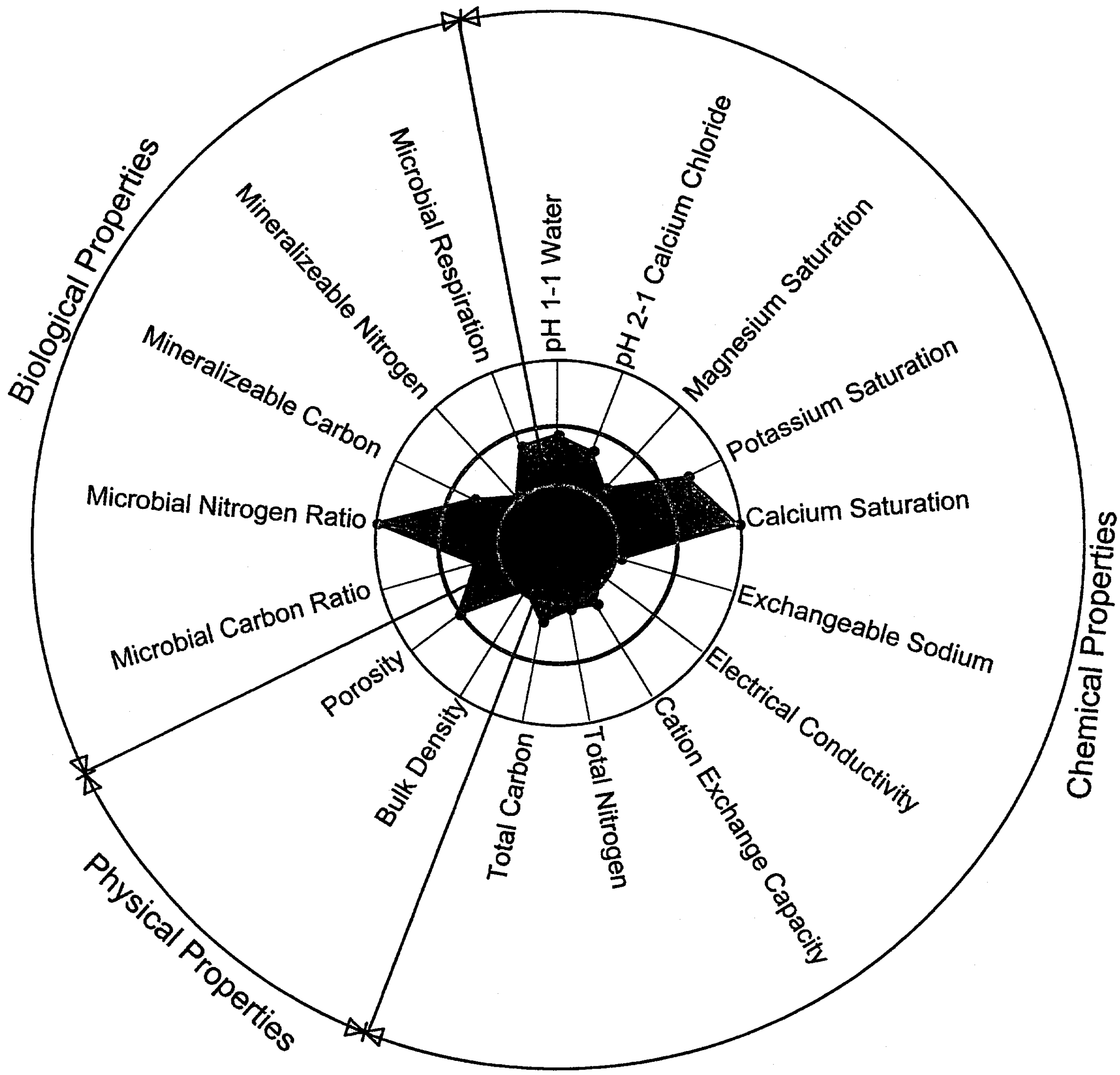

Figure 3.38. Composite soil quality index for seventeen soil quality indicators for untreated tee box soil 45 days (Oct. 26th, 2000) after last application date. The standardized values for calcium saturation and microbial nitrogen ratio are shown at 2x the upper control limit, while, the actual values are 3.75x and 4.25x the upper control limit respectively.

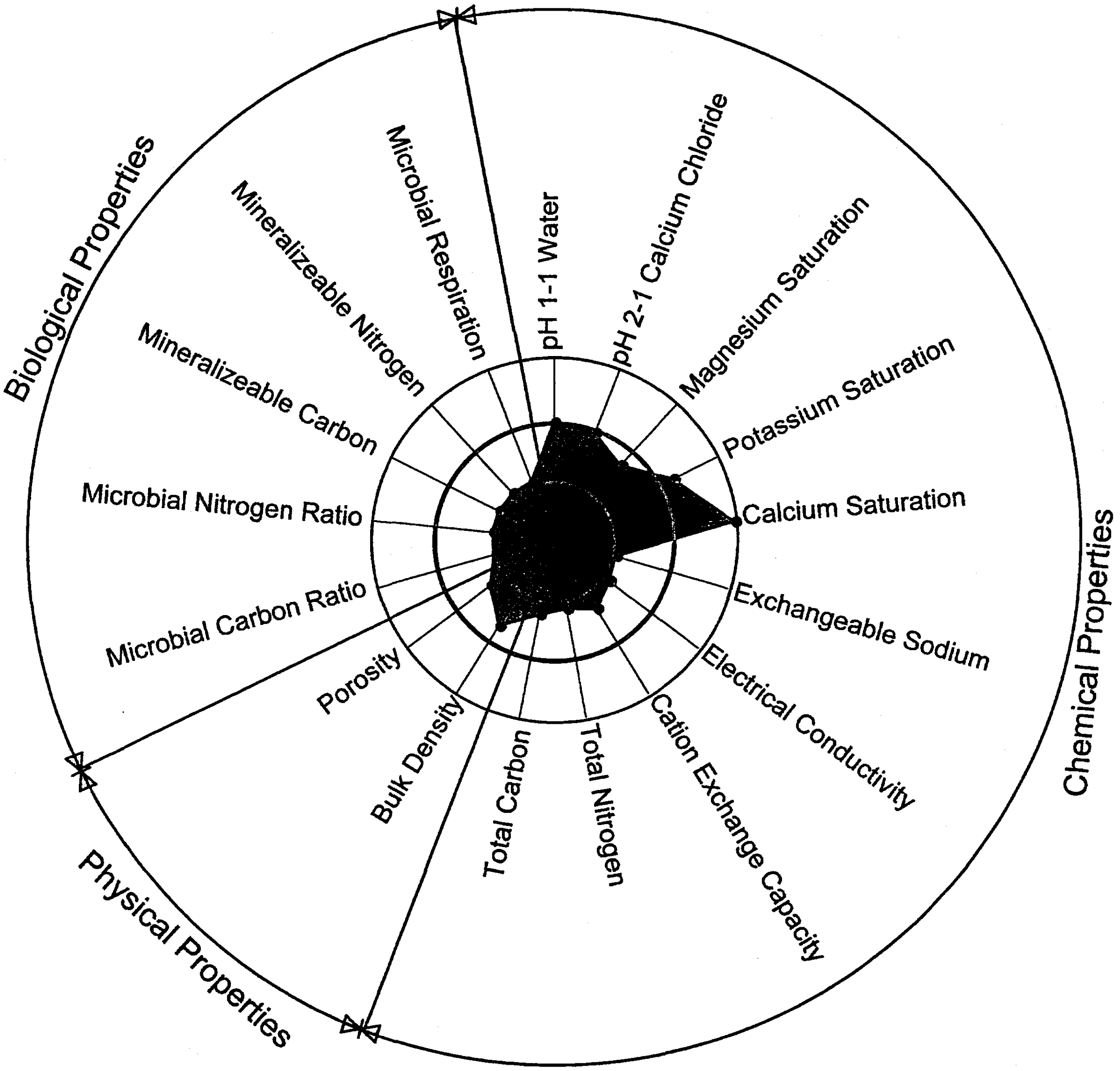

Figure 3.39. Composite soil quality index for seventeen soil quality indicators for swine 1x treated tee box soil before the first application date (May 11th, 2000). The standardized value for calcium saturation is shown at 2x the upper control value, while, the actual value is 4.25x the upper control limit.

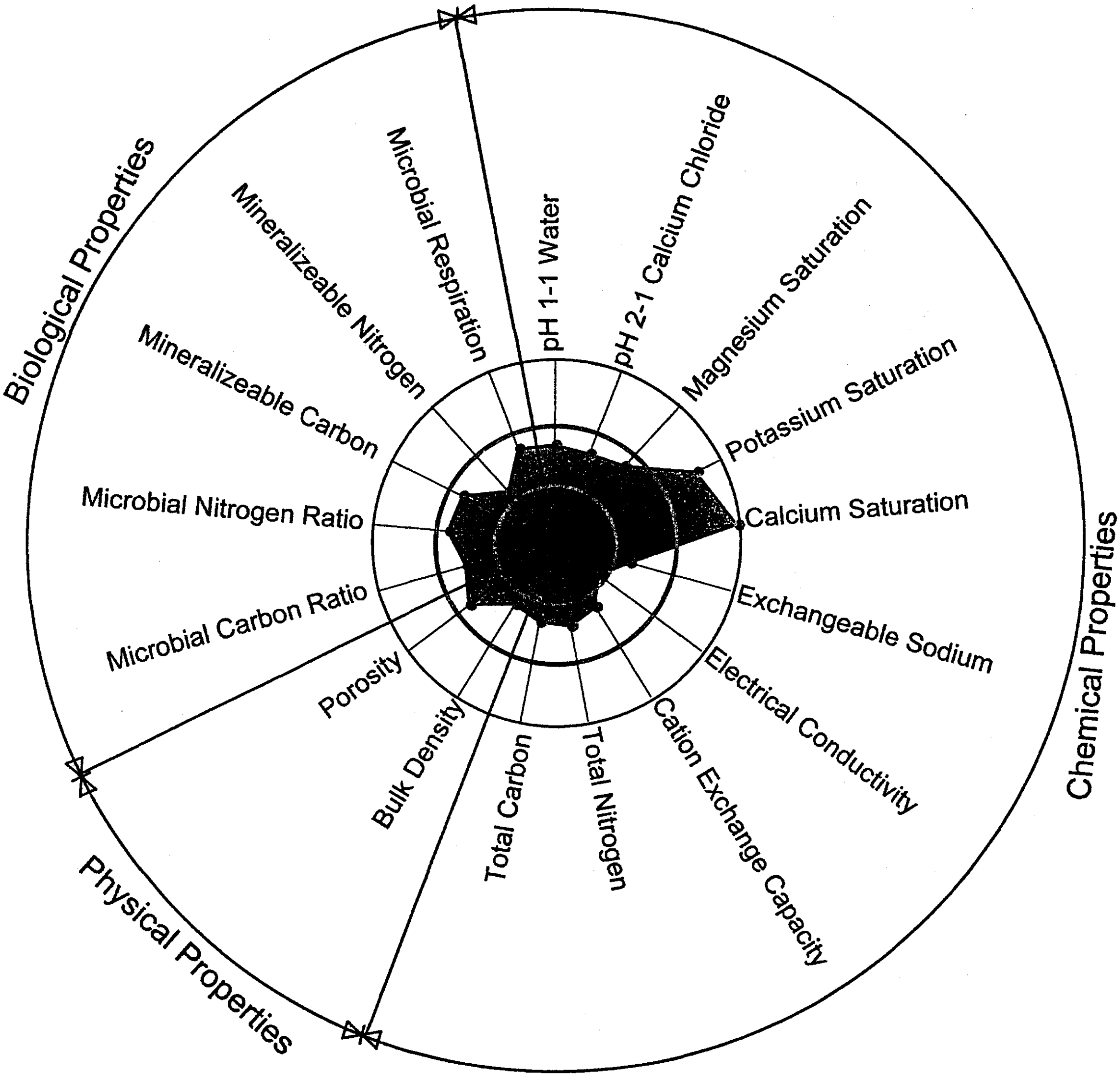

Figure 3.40. Composite soil quality index for seventeen soil quality indicators for swine 1x treated tee box soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for calcium saturation is shown at 2x the upper control limit, while, the actual value is 3.25x the upper control limit.

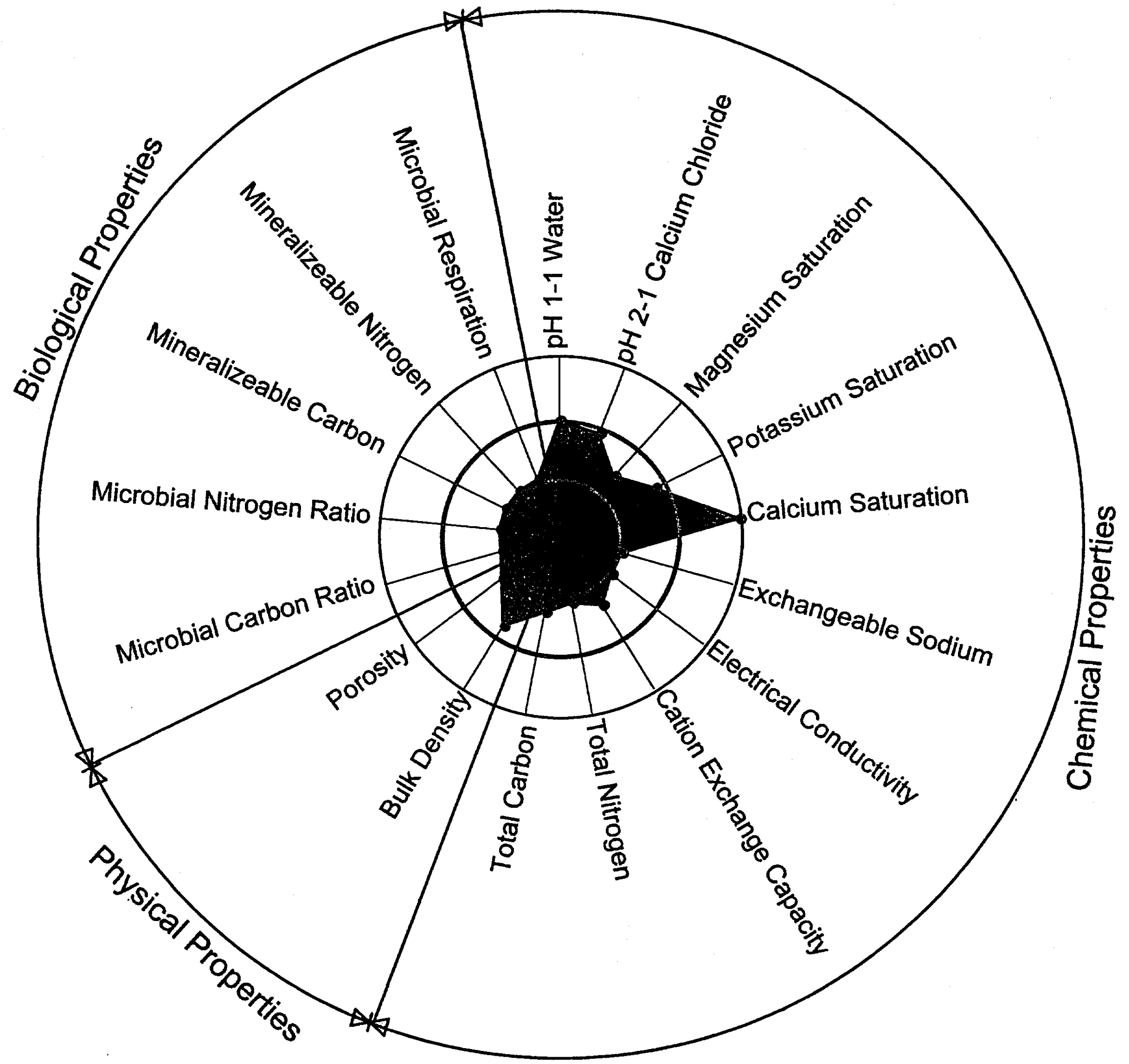

Figure 3.41. Composite soil quality index for seventeen soil quality indicators for swine 2x treated tee box soil before the first application date (May 11th, 2000). The standardized value for calcium saturation is shown at 2x the upper control value, while, the actual value is 4.75x the upper control limit.

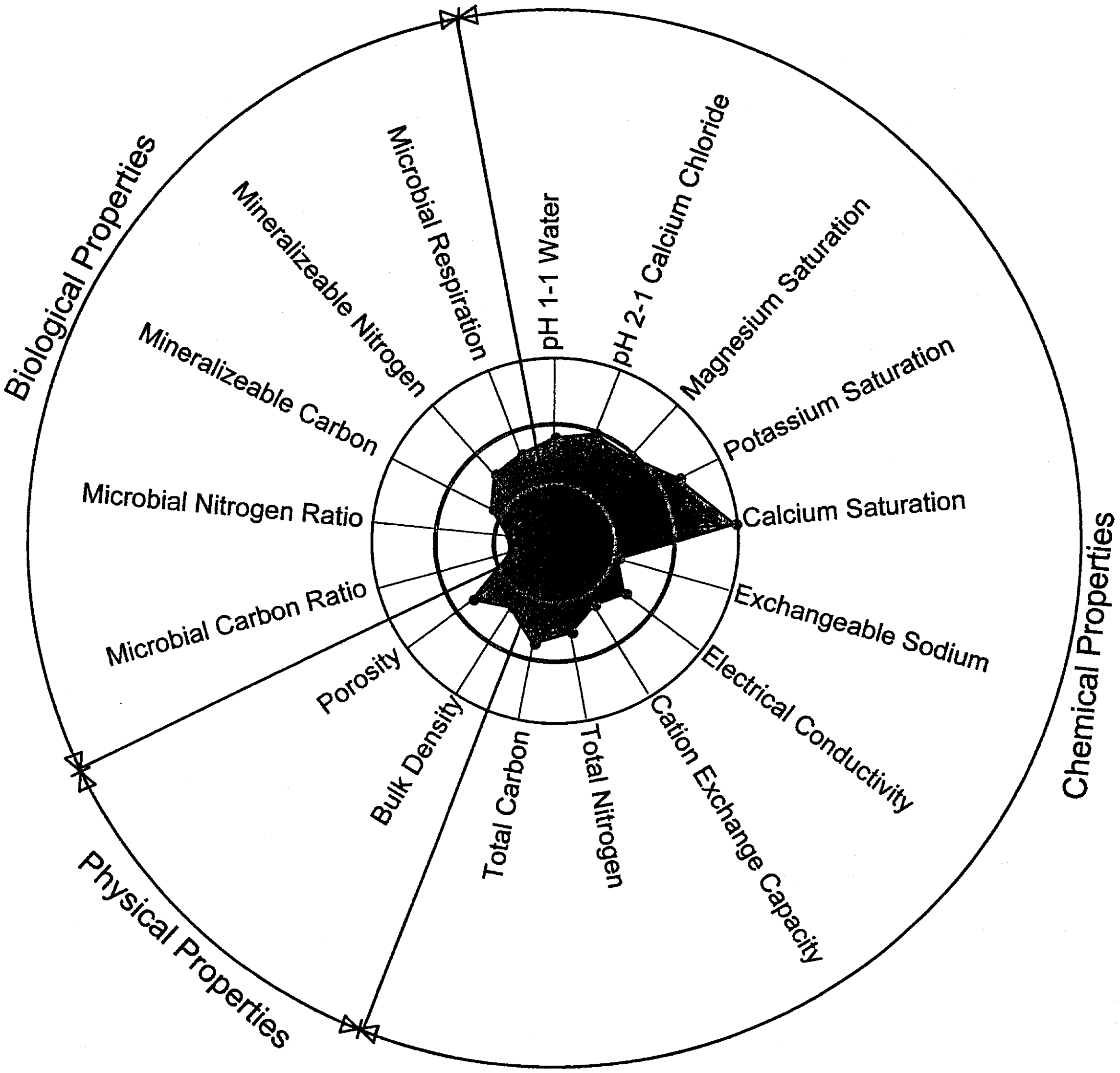

Figure 3.42. Composite soil quality index for seventeen soil quality indicators for swine 2x treated tee box soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for calcium saturation is shown at 2x the upper control limit, while, the actual value is 2.75x the upper control limit.

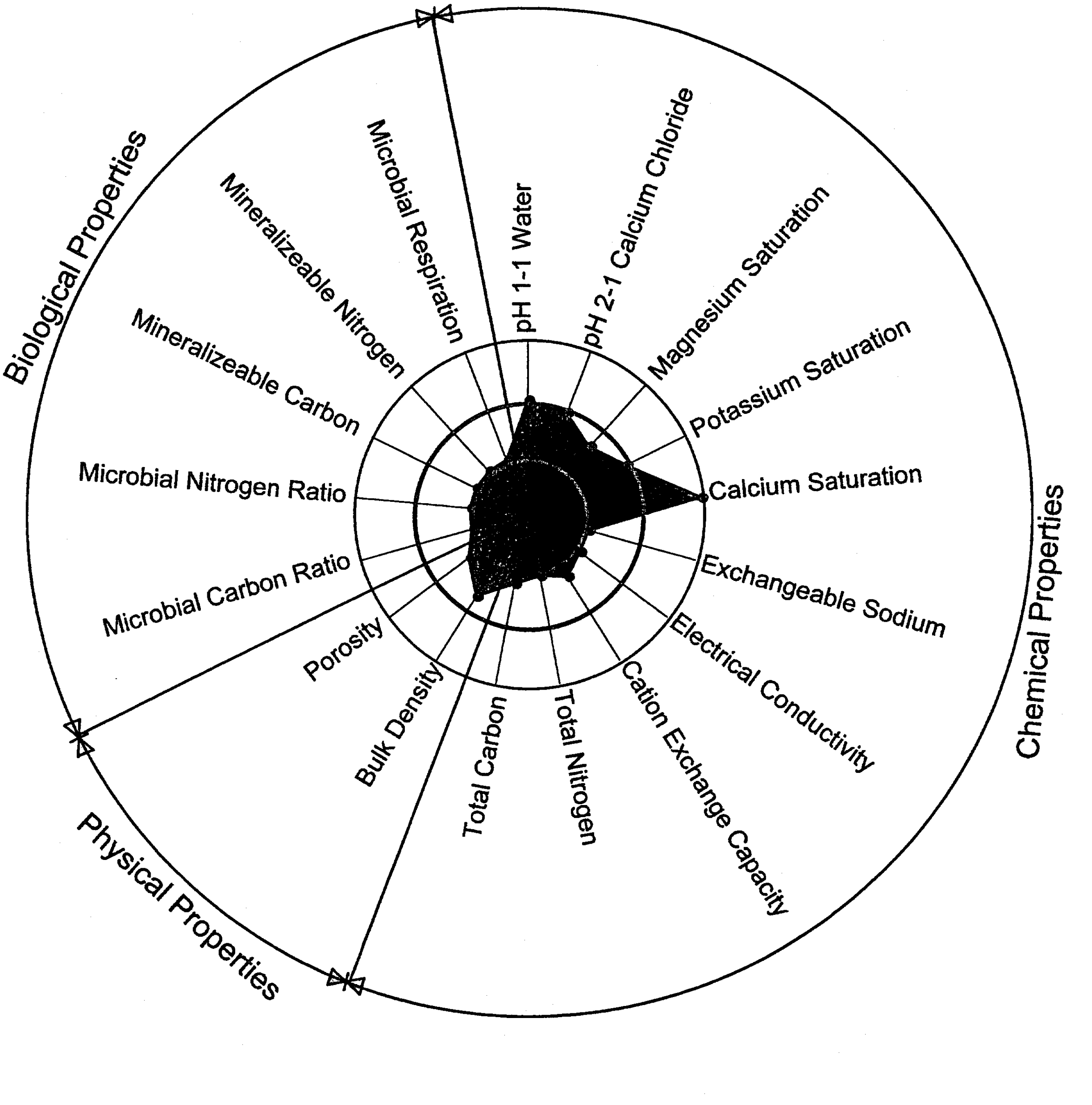

Figure 3.43. Composite soil quality index for seventeen soil quality indicators for dairy 1x treated tee box soil before the first application date (May 11th, 2000). The standardized value for calcium saturation is shown at 2x the upper control value, while, the actual value is 4.75x the upper control limit.

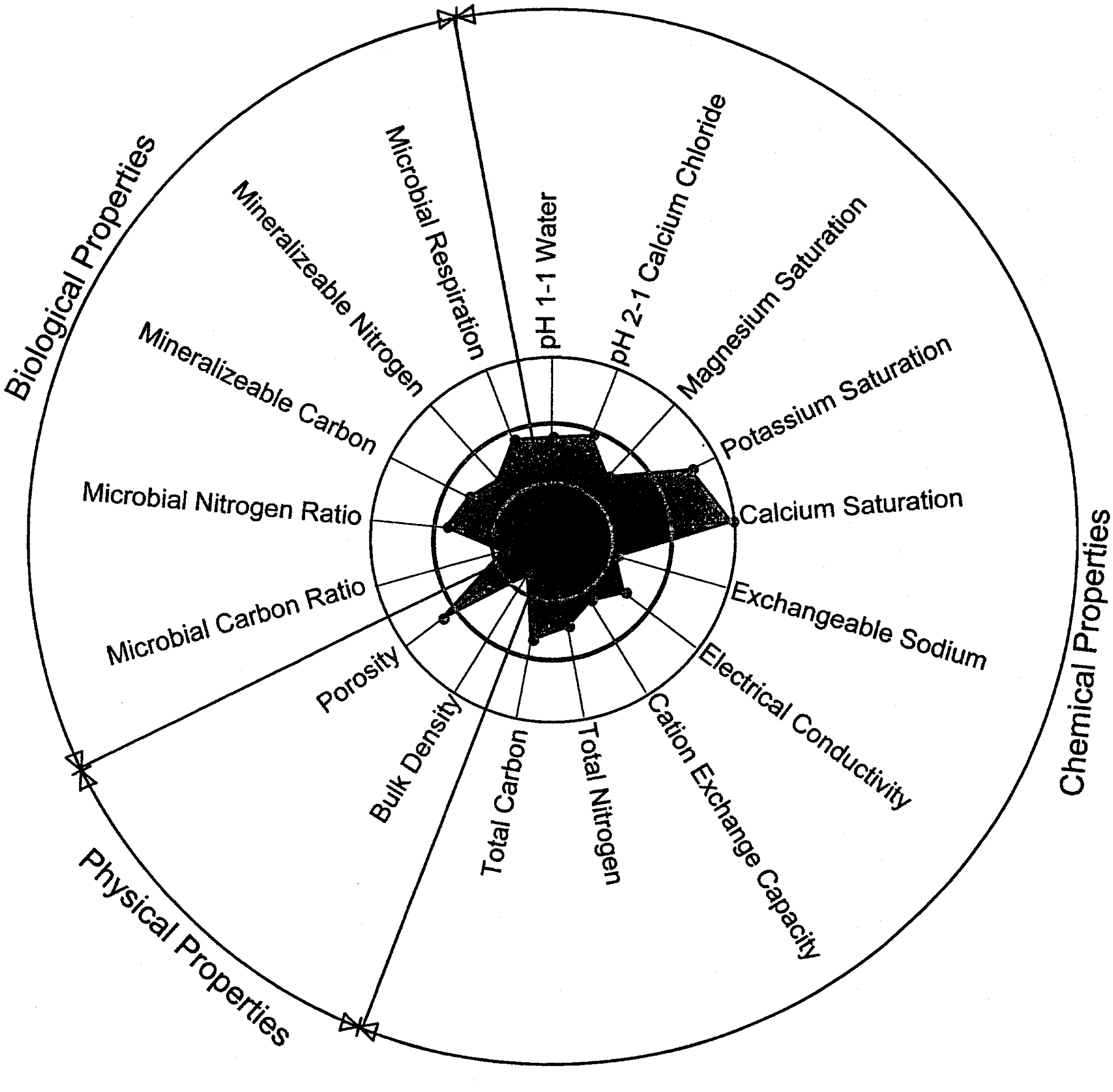

Figure 3.44. Composite soil quality index for seventeen soil quality indicators for dairy 1x treated tee box soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for calcium saturation is shown at 2x the upper control limit, while, the actual value is 3.75x the upper control limit.

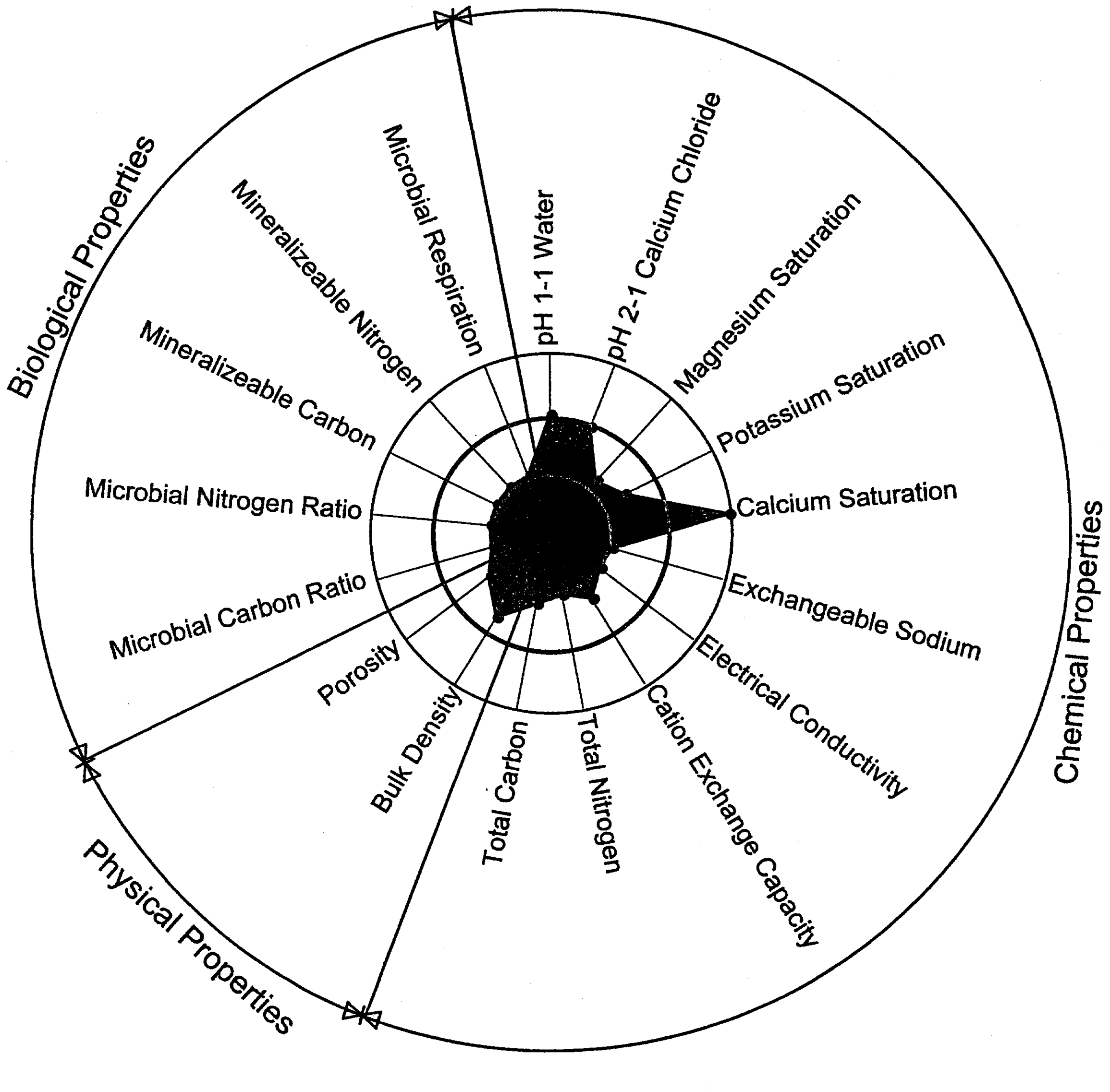

Figure 3.45. Composite soil quality index for seventeen soil quality indicators for dairy 2x treated tee box soil before the first application date (May 11th, 2000). The standardized value for calcium saturation is shown at 2x the upper control value, while, the actual value is 4.75x the upper control limit.

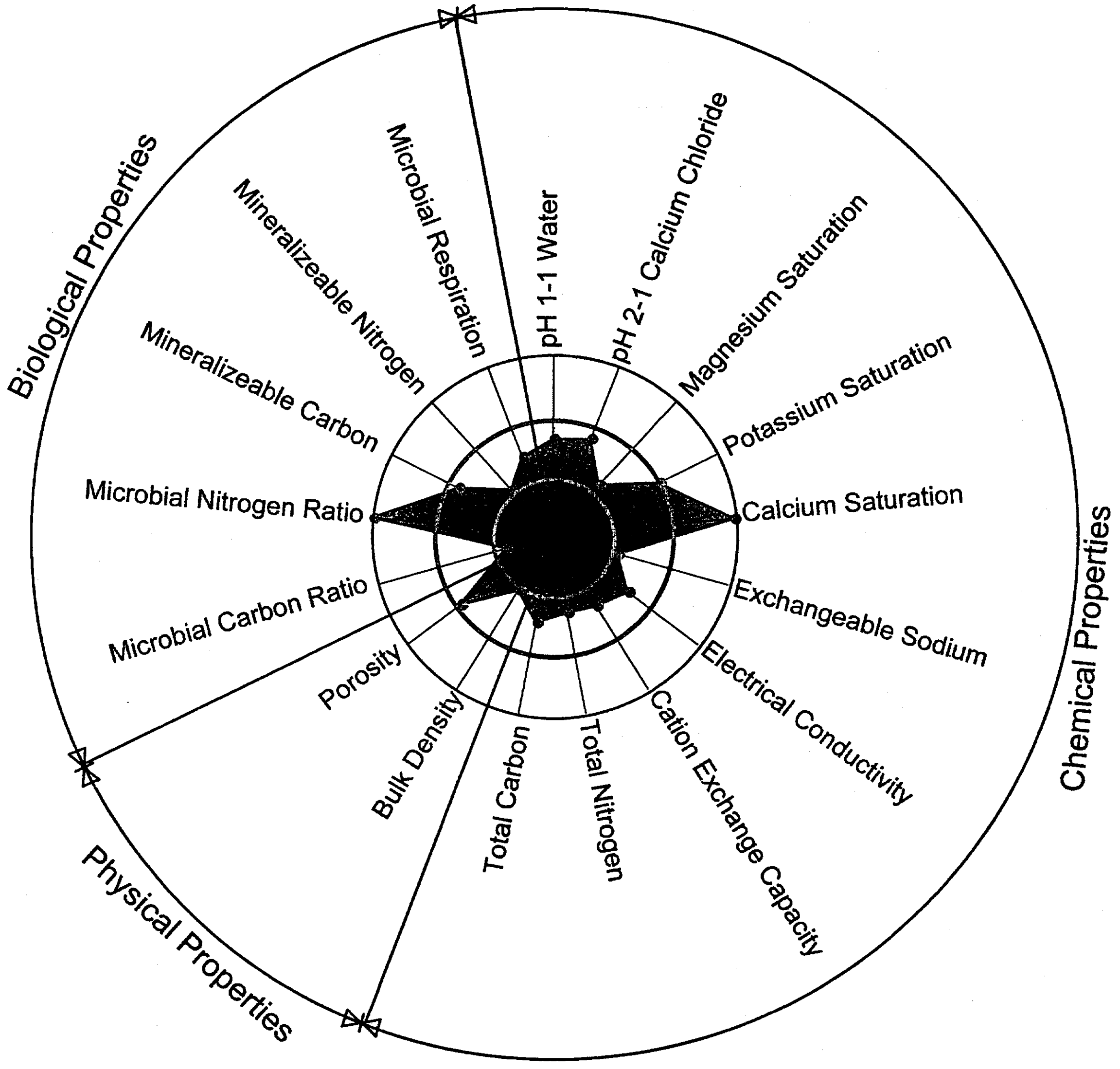

Figure 3.46. Composite soil quality index for seventeen soil quality indicators for dairy 2x treated tee box soil 45 days (Oct. 26th, 2000) after last application date. The standardized value for calcium saturation and microbial nitrogen ratio are shown at 2x the upper control limit, while, the actual values are 3.25x and 2.25x the upper control limit respectively.

3.6 CONCLUSION

The overlying goal of this project was to test the impact of compost amendments on soil quality and to assess the status of numerous soil quality indicators used measure the soil's capability for turf growth and development. Soil quality was quantified and evaluated using a comprehensive soil quality index that involved multiple indicators. These indicators can be grouped into three areas; physical, biological, and chemical soil properties.

Physical Soil Properties

Physical properties monitored were bulk density and soil porosity. These properties are inversely related to each other, an increase in one causes a decrease in the other property. Throughout the experiment, bulk density and porosity remained within allowable limits. However, a decrease in bulk density (increase in porosity) near the end of the study reached levels outside the sustainable range for dairy 2x in the green soil and the untreated and dairy 1x treated soil in the tee box areas.

Chemical Soil Properties

Chemical properties monitored were exchangeable cations, nutrient levels, soluble salts and soil pH. Addition of the swine and dairy amendments impacted some chemical properties. Soil pH decreased over the six-month period possibly due to the use of fertilizers and other herbicides. Calcium saturation decreased except for an across-the-board increase for all treatments in the green soil in August. Potassium saturation tended to decrease in the high-sand green soil. These trends may be related to the application of fertilizers, high nutrient uptake by grass roots, and leaching. Potassium levels in the tee box areas increased over the six-month period and were outside the upper control limit.

The increase in K may be due to low rates of leaching or grass clippings left on the site (which were removed on the high-sand green). Magnesium saturation decreased in the high-sand green, however levels were still above upper control limits. In the tee box, Mg saturation was within the sustainable range except for the two areas receiving swine compost, which slowly increased and reached levels above sustainability from June to October. Electrical conductivity (soluble salts) increased but still remained below the upper control limits, which would signal salinity, a degraded status. An increase in soluble salts was observed in all areas receiving compost applications; however, the dairy amended areas experienced the greatest increase. The increasing levels of soluble salts might be an indicator of possible degradation under continued application. The continued application of these amendments requires careful management to guard against soluble salt accumulation. At high application rates, dairy compost increased soluble salts from near 0.5 dS m^{-1} to near 2.0 dS m^{-1}. Values above 4.0 dS m^{-1} are considered a state of soil degradation. Cation exchange capacity more than doubled for both the swine treatments and the dairy 1x treatment in the high sand green. In the tee box areas CEC decreased slightly, possibly the result of increased oxidation of organic matter. Total carbon and nitrogen also increased in both the high-sand green and tee box soils except for the untreated in the tee box soils. The increase in total carbon and nitrogen is one reason why the CEC increased in the high-sand green soil. Overall, an increase in both total C and N corresponds to an increase in soil organic matter. This is very important in the high-sand green which was constructed with no mixture of peat or other organic material.

Biological Soil Properties

Biological properties monitored were microbial biomass C and, mineralizable C and N, and microbial respiration. Due to low inherent organic matter and microbial activity, a high degree of variation was observed in our measurements. The results represent data collected only from July to the end of the experiment in October. For almost all microbial soil quality indicators, decreasing trends were observed in the high-sand green while considerable fluctuations were observed in the tee box areas. Decreases in biomass can probably be attributed to high soil temperatures followed by an increase in organic matter oxidation. The amount of MBC within TC (MBM C/Total C) and the amount of MBN within TN (MBM N/Total N) were used to provide a better estimate of changes in soil organic matter and organic matter quality compared to their individual components. In all treatments, a decrease in both the MBC:TC and the MBN:TN ratio was observed. The MBC:TC ratio for the untreated area and the MBN:TN for the swine 2x treated area were both below the lower control limits . In the tee box soils, the ratio of MBC:TC and MBN:TN fluctuated considerably, however, it is difficult to determine the impact compost application had on these properties due to the fertilizer applications and frequent irrigation. Mineralizable N is the only biological property that didn't follow the same trend as the other biological indicators. In both the high-sand green and tee box areas fluctuations were observed from July till October. Since little research has been conducted on how this indicator should be interpreted for turf soils, it is difficult to establish if measured values were within acceptable levels.

With the exception for the MBC:TC and MBN:TN ratios, no sustainable limits were easily established for any of the biological soil quality indicators. Further research on these indicators in turf soils may prove useful in the determination of sustainable limits for turf grass soils.

An increase in CEC, EC, and TC was observed in areas treated with organic amendments however, the high degree of management, fertilizers and irrigation makes it difficult to differentiate changes in certain soil quality indicators such as K saturation, TN, and mineralizable N. The use of animal manures and other organic wastes has previously been suggested as a promising method of enhancing the quality of turf soils. The design of the study along with numerous fertilizer applications throughout the summer precluded a complete assessment of the impact animal waste compost has on turf soil quality. However, further research such as simulated turf plots or plots under controlled conditions may prove useful to further quantify the impact organic amendments would have on various soil quality indicators. The use of spider/radar graphs to monitor and index soil quality has been shown to be a potential tool for golf course managers. However, the lack of research and literature on microbial indicators as well as some chemical indicators presents problems in assessing individual soil properties. Further research looking at soil fertility, microbial activity, and influence of xenobiotics will help to strengthen soil quality indices and the use of a multiple indexing system to monitor soil quality.

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