

**The Environmental Fate and Impact of
Perasan[™] and Perasan[™]‘A’
(Equilibrium Mixtures of Peroxyacetic Acid
and Hydrogen Peroxide) in Soil**

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Abstract

The peroxyacetic acid and hydrogen peroxide ingredients in Perasan products decompose rapidly upon contact with a Central Valley, CA sandy loam soil. Only about 1/3 of the nominal peroxyacetic acid dose was detectable one minute after contact. Both components were essentially depleted within 20 minutes. The rapid destruction is attributed to the high transition metal components (primarily iron and manganese) of the soil that catalyzes the reaction with the generation of oxygen gas. Soil saturated with a 1.5% v/v solution of Perasan A exhibits a reduction in pH and an increase in electrical conductivity. However, the effect is transient and within 9 days both the pH and electrical conductivity rebound to values close to those obtained for untreated soil (control). Biodegradation of acetate ions by soil microorganisms is suggested to explain this occurrence.

I. Introduction

To avoid possible confusion by the reader, Perasan (an equilibrium mixture of 15% Peroxyacetic Acid (PAA) and 22% Hydrogen Peroxide) will be referred to hereafter as 'Perasan 15'. Perasan 'A' (an equilibrium mixture of 5.6% Peroxyacetic Acid (PAA) and 27% Hydrogen Peroxide) will be referred to hereafter as 'Perasan 5.6'.

These peroxygen-based products are under consideration for an increasing number of agricultural applications due to their powerful oxidizing potential, lack of toxic or noxious disinfection by-products, and a friendly environmental profile, wherein the degradation products are ultimately carbon, oxygen, and water.

Some present and future applications include the use as a slimicide and algacide in drip-irrigation systems; as a fungicide and bactericide on pre and post harvest crops, as a fungicide/ mildewcide soak for seeds prior to planting, and as an algacide for numerous greenhouse and horticultural applications. In many of these agricultural uses, the product will contact the ground soil. Since users of these products will need to have knowledge of the proper and safe use of these peroxy compounds, this study was performed in order to assess the environmental fate and impact of Perasan 15 and Perasan 5.6 in soil.

A sandy loam soil was saturated with solution of Perasan 15 (containing 1027 ppm PAA and 1468 ppm H₂O₂) and the decay profiles of the PAA and hydrogen peroxide were tracked. The same sandy loam soil was then saturated with a 1.5% v/v solution of Perasan 5.6. Then, for the next several hours, the pH and conductivity of the treated soil was monitored and compared to that of the untreated control soil sample employing only de-ionized water. All soil samples were covered during standing periods to prevent water evaporation, and the pH and conductivity was examined every few days for the next 9 days.

II. Experimental Design

A sandy loam soil was removed from a fallow unimproved pasture adjacent to the Enviro Tech property in Modesto, California. This was sieved of stones and homogenized in a rotary mixer for 30 minutes.

A soil saturation index (SSI) was determined by measuring and mixing the amount of water needed to flood the soil pores and produce a thin standing film of water on the surface (soil saturation). A small portion of the resultant mud was vacuum filtered to remove the solids. The pH and conductivity of the filtrate were measured with a newly calibrated pH – Conductivity probe (Hanna Instruments HI 9812 pH-EC-TDS meter).

A 1027 ppm stock solution of PAA (from Perasan 15) was prepared in de-ionized water. Using the calculated soil saturation index, sufficient stock solution was mixed into the soil and a stopwatch was started. Within 1 minute a small portion of the saturated soil was vacuum filtered and diluted for analysis of PAA and hydrogen peroxide by the modified DPD methods (See Appendix). This process was repeated as several more times over the next 30 minutes until no more PAA or hydrogen peroxide was detectable.

Another portion of the same soil was treated to the soil saturation index with a 1.5% v/v solution of Perasan 5.6. An aliquot of the saturated soil was vacuum filtered for measurement of the pH and conductivity. Monitoring continued for the next several hours. The saturated soil was then covered with foil to prevent water evaporation, and the pH and conductivity were checked every few days for the next 9 days.

III. Results and Discussion

The soil saturation index (SSI) was determined by mixing the soil with just sufficient deionized water to fill the pores and produce a thin standing film of water on the surface. Vacuum filtration of the slurry produced a liquid whose pH and conductivity were measured at various intervals.

The data in Table I reports the soil saturation index, pH and conductivity of the sandy loam 'control' soil.

Table I

Soil Saturation Index	0.757
pH	6.2
Conductivity/ μScm^{-1}	750

Figure 1 plots the concentration of PAA as a function of time when a stock solution of Perasan 15 (1027 ppm PAA) is mixed with a sandy loam soil. It can be seen that the degradation of PAA is very rapid. Less than half of the PAA applied to the soil is recovered analytically 1 minute after contact. Within 9 minutes, less than 0.2% of the initial PAA charge can be detected and the soil becomes essentially devoid of PAA after 13 minutes.

Figure 2 demonstrates that the decay of the hydrogen peroxide component of Perasan 15 is equally dramatic. From an initial nominal charge of 1468 ppm less than 1 ppm was detectable 19 minutes later.

The decomposition reactions of PAA and hydrogen peroxide were accompanied by the generation of large quantities of oxygen bubbles. The saturated soil mixture seemed to effervesce. This would indicate that the depletion of PAA and hydrogen peroxide is principally a catalytic decomposition, accelerated by the naturally occurring transition metal components in the soil. The alluvial soils of California's central valley are particularly rich in iron and manganese minerals that are devastating to the stability of peroxygen compounds. The soil used in this study is quite typical, and contains 2-3% total iron and 600 ppm manganese by weight.

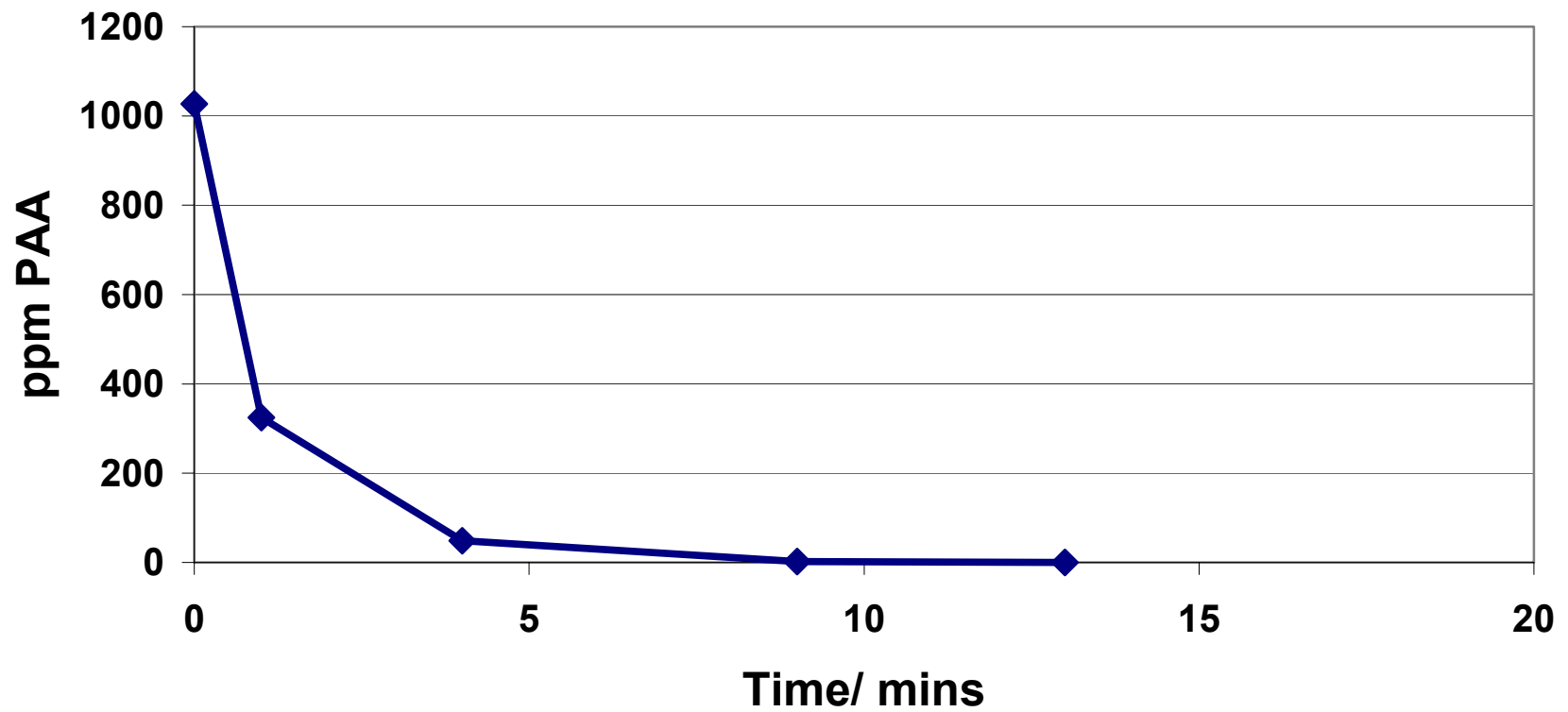
Figure 3 illustrates how the pH varies when the soil is saturated with a 1.5% v/v solution of Perasan 5.6. Initially the vacuumed extract drops to pH 4.7, compared to the naturally-occurring pH of 6.2 obtained in deionized water. It is clear that soil possesses some buffering capacity, as the pH of a 1.5% v/v Perasan 5.6 solution is 2.49 when prepared in deionized water. It can be seen that this initial pH excursion is only transient, and the pH of the soil starts to rebound immediately, and stabilizes close to the naturally-occurring soil pH at around 132 hours.

As Figure 4 shows, when the soil is mixed with 1.5% v/v Perasan 5.6 the conductivity increases to $1900 \mu\text{Scm}^{-1}$ compared to a naturally-occurring $750 \mu\text{Scm}^{-1}$ that was obtained with deionized water. At the pH of 4.7 the acetic acid component of the saturated soil exists largely as the ionized acetate ion, which contributes additively to the conductivity. However, it can also be seen that the conductivity steadily falls with time, and after 204 hours the soil conductivity has rebounded almost back to its naturally-occurring value. Removal of acetate ion by biodegradation to carbon dioxide and water is the most plausible explanation for this trend. Indigenous soil bacteria would not have been completely eliminated upon treatment with PAA because of the rapid degradation kinetics, and it seems likely that these microorganisms would rapidly metabolize the acetate ion as a nutrient.

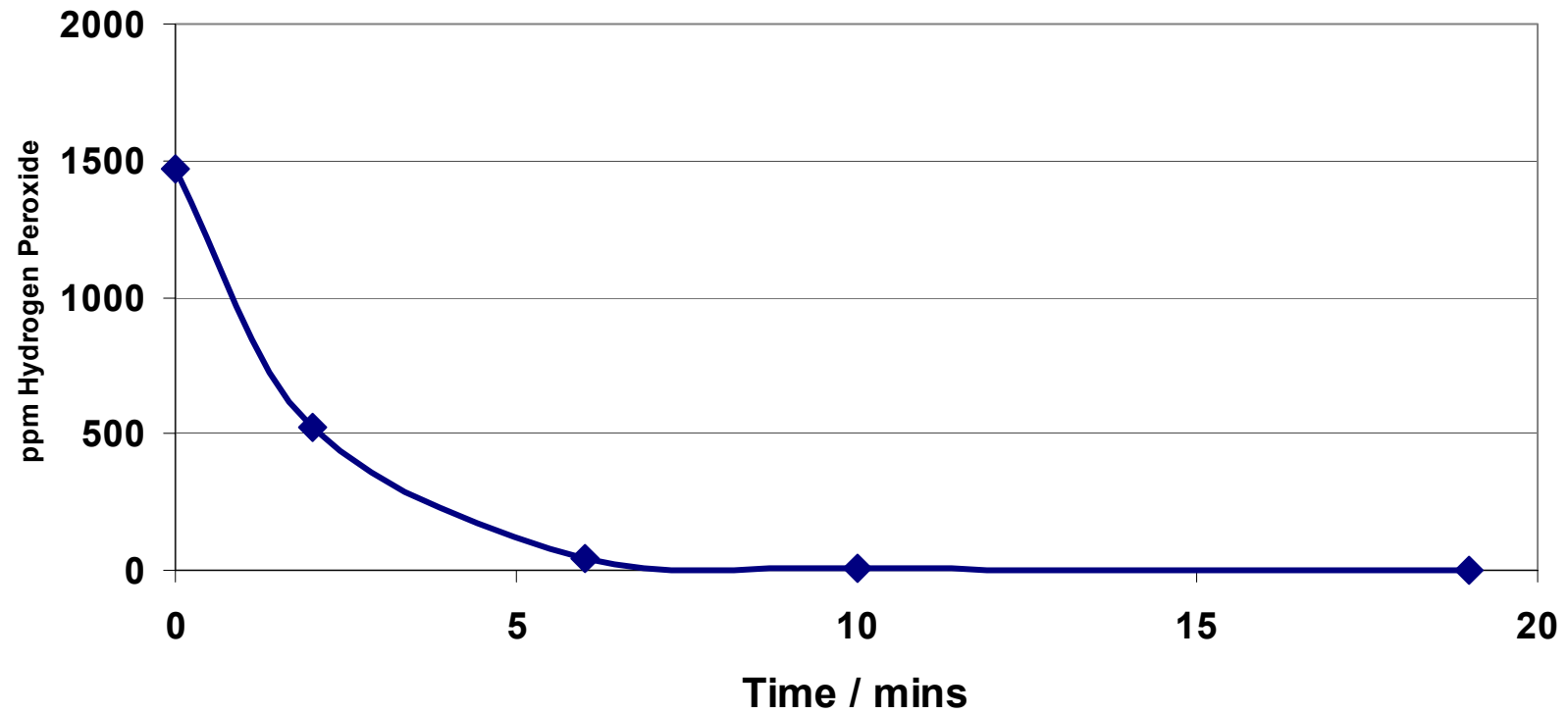
Findings and Conclusions

- The peroxyacetic acid and hydrogen peroxide ingredients in Perasan_m products are very unstable when contacted with a central valley, CA sandy loam soil.
- Only about 1/3 of the peroxyacetic acid (1027 ppm dose) was detectable one minute after contact, and only a trace amount (0.33 ppm) was present after 13 minutes.
- Both peroxyacetic acid and hydrogen peroxide were essentially depleted from the soil 20 minutes after contact.
- The high transition metal components (especially iron and manganese minerals) in the soil catalyze the decomposition reactions and generate profuse oxygen gas.
- Soil saturated with 1.5% v/v solution of Perasan 5.6% acquires a pH of 4.7 compared to the naturally-occurring pH of 6.2 obtained for the untreated soil.
- Soil saturated with a 1.5% v/v solution of Perasan 5.6% acquires an electrical conductivity of $1900 \mu\text{Scm}^{-1}$ compared to the naturally-occurring electrical conductivity of $750 \mu\text{Scm}^{-1}$ for untreated soil.
- Both the pH and electrical conductivity rebound to values close to those obtained for untreated soil with 9 days.
- Biodegradation of acetate ion by soil microorganisms is the mechanism by which the treated soil restores itself to its former quality.
- The inert ingredients (stabilizers) are biodegradable, and break down to elemental phosphorous and carbon within a few days.

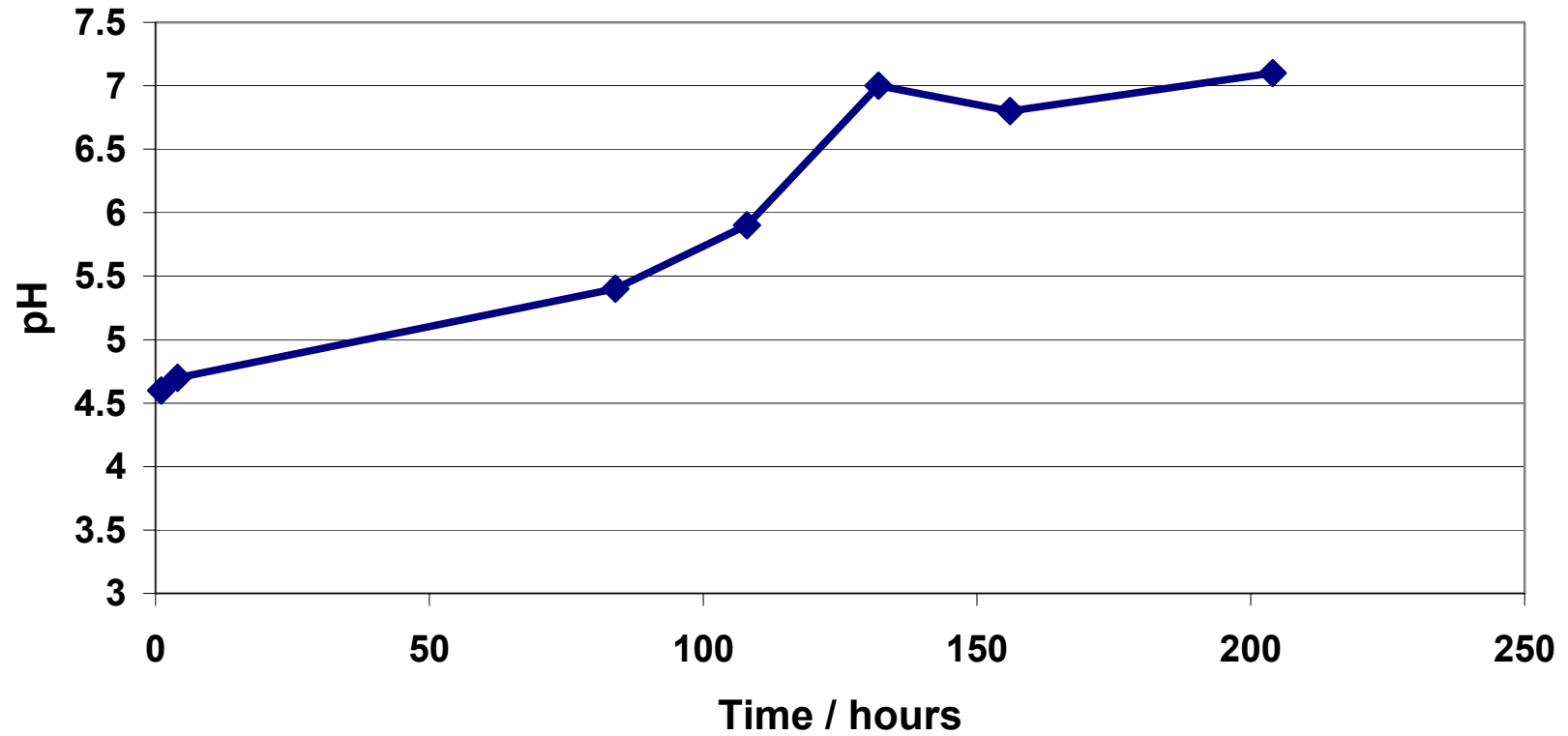
**Figure 1: Degradation of PAA in Soil
(1027 ppm PAA from Perasan 15)**



**Figure 2: Degradation of Hydrogen Peroxide in Soil
(1468 ppm from Perasan 15)**



**Figure 3: Variation of Soil pH with Time
(1.5% v/v Perasan 5.6)**



**Figure 4: Variation of Soil Conductivity with Time
(1.5% v/v Perasan 5.6)**

