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To: Falcon Waterfree Technologies

I am a Professor at Virginia Tech where I conduct research on physiochemical treatment and internal corrosion processes. Over the years, I have worked with drinking water and wastewater utility personnel, industries, researchers and homeowners on internal corrosion of plumbing materials. My research group has executed several million dollars in externally funded corrosion research grants for utilities, private companies, the National Science Foundation, the United States Environmental Protection Agency, the Copper Development Association and the American Water Works Research Foundation. I have also published more than 60 peer reviewed journal articles and presented more than 100 additional papers at national and international research conferences. In 1996, I received a "National Science Foundation Presidential Faculty Fellowship," an honor from the White House given to only 20 professors in the nation each year, in large part for my work on internal corrosion processes. This, combined with my consulting experiences, qualify me as an expert to judge the relative corrosiveness of undiluted human urine in metallic plumbing versus water that would normally be present in sewer lines.

This letter reports on experiments conducted to determine the relative corrosiveness of pure concentrated urine to various pipe materials. The main consideration is whether concentrated urine is more aggressive than the same urine diluted with water. That is, during normal urinal operation, urine is diluted with the local tap water, whereas with the Falcon system no tap water is used.

Two points of comparison are of interest. The first is a relative comparison to a well water of relatively low corrosiveness and conductivity (40 ppm chloride, 20 ppm sulfate, 40 mg/L alkalinity, 40 mg/L hardness and pH 8.9). The second is to the same water but with an added 100 mg/L chloride and 200 mg/L sulfate at pH 7.8. Even though this second water is termed "aggressive" herein, in the scheme of public drinking water it is only considered moderately aggressive water.

The experiment was started on January 15, 2004 and it ran for 30 days. An apparatus was constructed that allowed the test solution to pass through a series of small metal samples. These included iron, galvanized and copper (Figure 1 and Figure 2). These small pieces of metal, termed "coupons," are well accepted among the scientific community for use in corrosion studies to measure degradation of metals. These coupons are identical in composition to materials typically used in plumbing drain pipes. Small plastic tubes were connected to hold each sample in isolation. During flow, the sample was totally surrounded by the test solution, whereas when flow was "off" the water drained away and the sample was surrounded by moist air and residual urine. The flow was "on" for 1 minute at 5 minute intervals (1 minute flow and 4 minutes without flow) during a 9 hour "business day." There was no flow during the rest of the day. The samples exposed to the pure urine were continually wet, simulating concentrated urine sitting on the metal.

Urine was collected each day from a family of four living in the same household. The urine maintained roughly the same pH throughout each day because the system was "closed" to most transfer of carbon dioxide. To create urine diluted with tap water(s), urine was diluted 1 part urine to 17 parts tap water, simulating the dilution of urine in a flushed urinal. Flow through the device was turbulent with a Reynolds number of roughly 3000 in the case of the undiluted urine. Total flow rate through the concentrated urine apparatus was decreased by a factor in rough proportion to the volume of water expected to be "flushed" each for each use during normal operation. Specifically, 0.3 liters was passed during each flow event through the metal samples exposed to concentrated urine whereas 5 liters was passed through the samples exposed to urine diluted with tap water. Thus the velocity of water through the samples of concentrated urine was lower by about a factor of 17, as would occur in practice.

The results conclusively demonstrate that for typical steel materials, including galvanized and iron (Figures 3, 5 and 6), the concentrated urine is much less corrosive than normal diluted and flushed urine as occurs in a flush urinal. It appears that there are substances in urine that directly inhibit corrosion of normal mild and galvanized steels used in plumbing pipes. For copper (Figure 4), the weight loss during exposure to concentrated urine was in between that observed for the two tap waters.

It is well understood that the only meaningful comparison in such studies is the relative weight loss among the different samples. There is a high absolute weight loss in this experiment due to the small size and thickness of the coupons relative to real plumbing pipes; indeed, the smaller size gives a better signal (weight loss) to noise (total weight) effect in a one month test. Normal thickness plumbing materials might require a year of testing before a meaningful difference could be obtained.

Overall, this experiment demonstrates that concentrated urine is not problematic for steel or copper plumbing materials. In fact, the Falcon operational scenario would appear to reduce corrosion of steel materials, while it is no worse than many tap waters for copper materials.

Please contact me at (540)231-7236 if you should have any questions about this report.

Regards,

Marc Edwards
Professor of Civil and Environmental Engineering
Virginia Tech

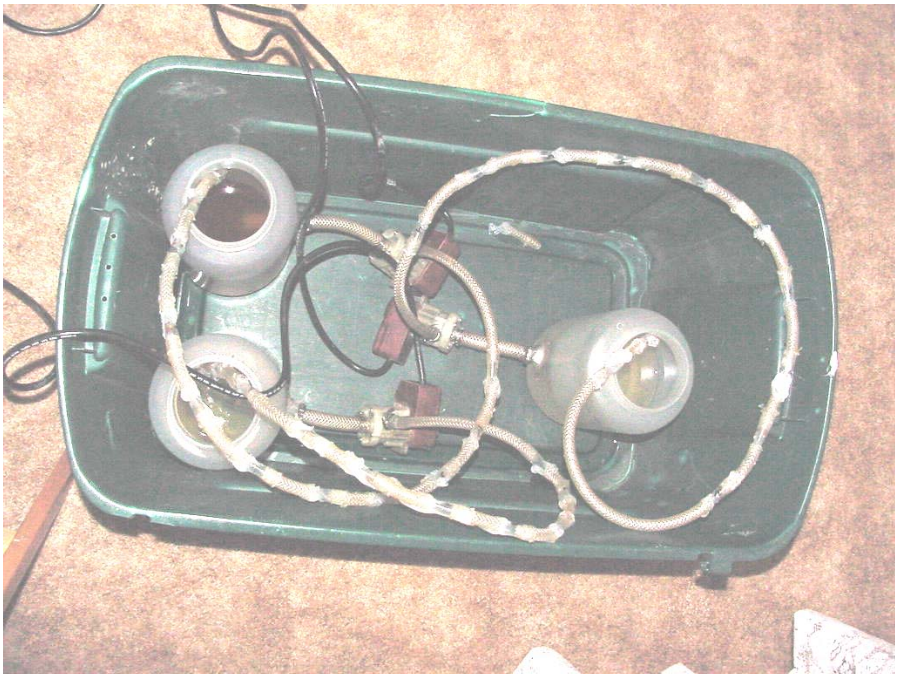

Figure 1. Picture of experimental apparatus with three exposure loops.

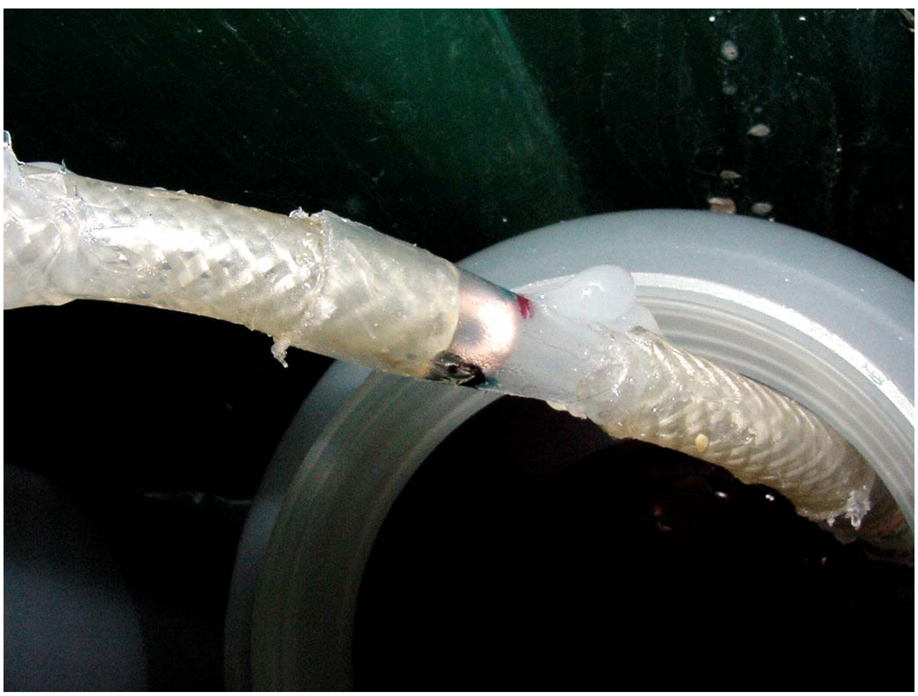

Figure 2. Close up of sample holder. Copper sample is visible through clear plastic tubing.

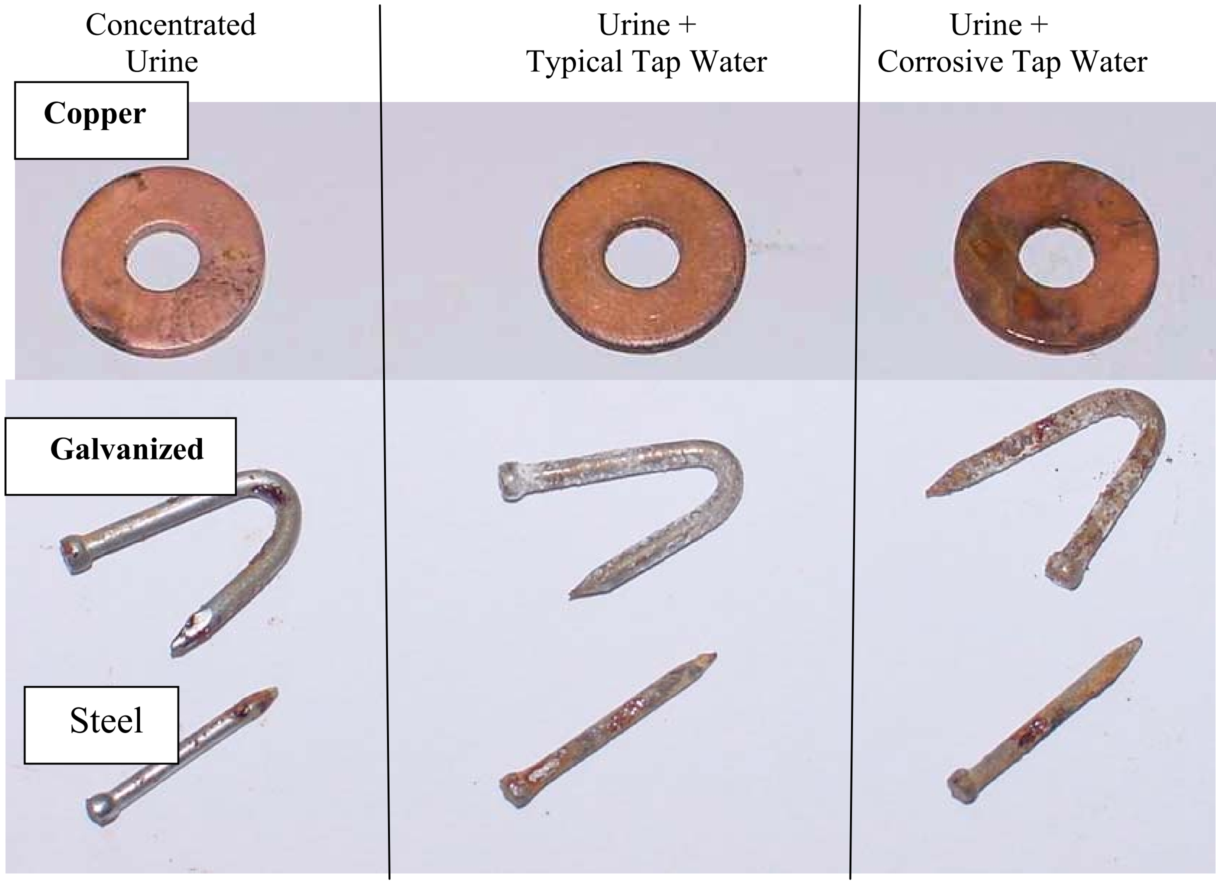

Figure 3. Picture of samples after exposure to indicated solution.

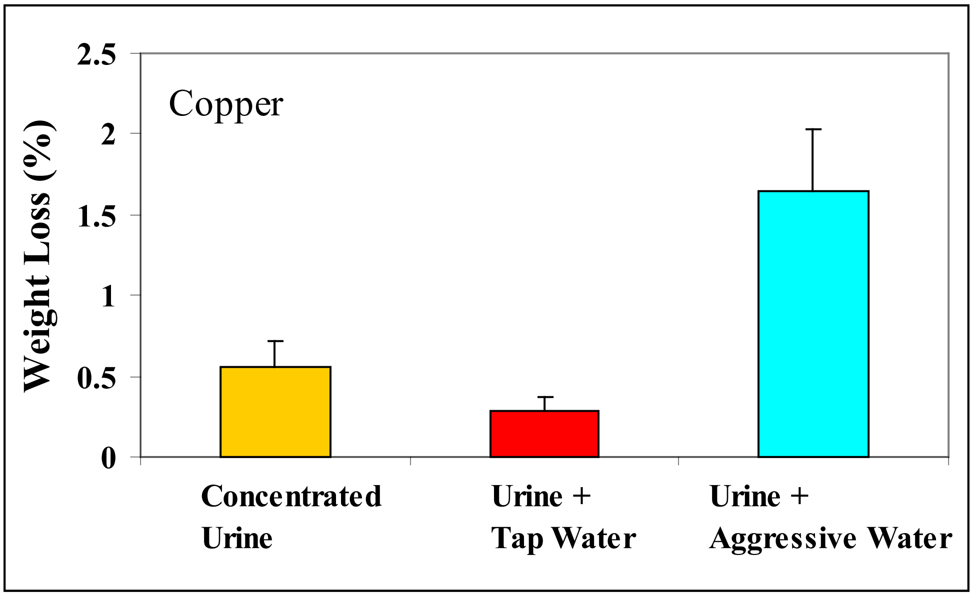

Figure 4. Copper weight loss in indicated solution.

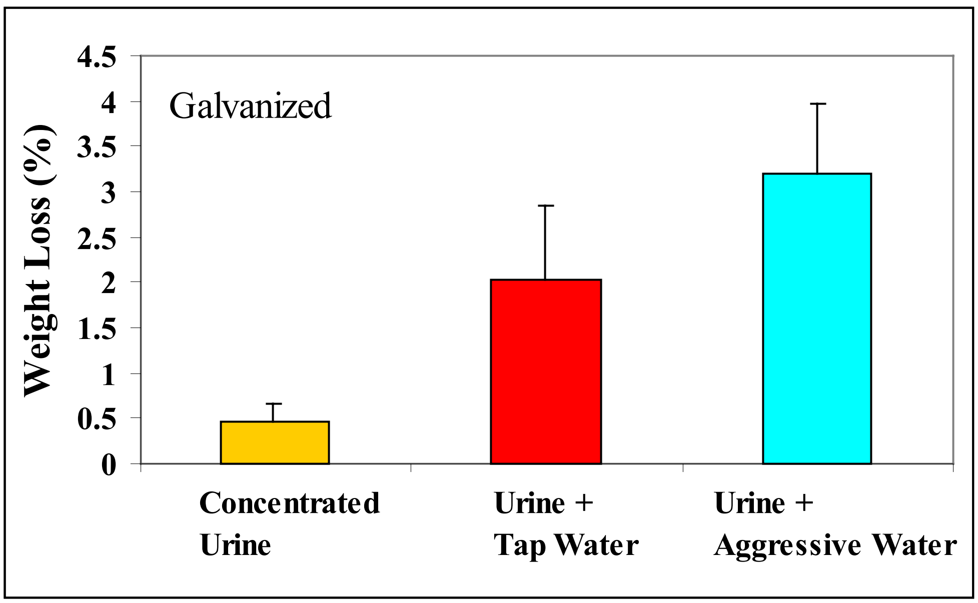

Figure 5. Galvanized weight loss in indicated solution.

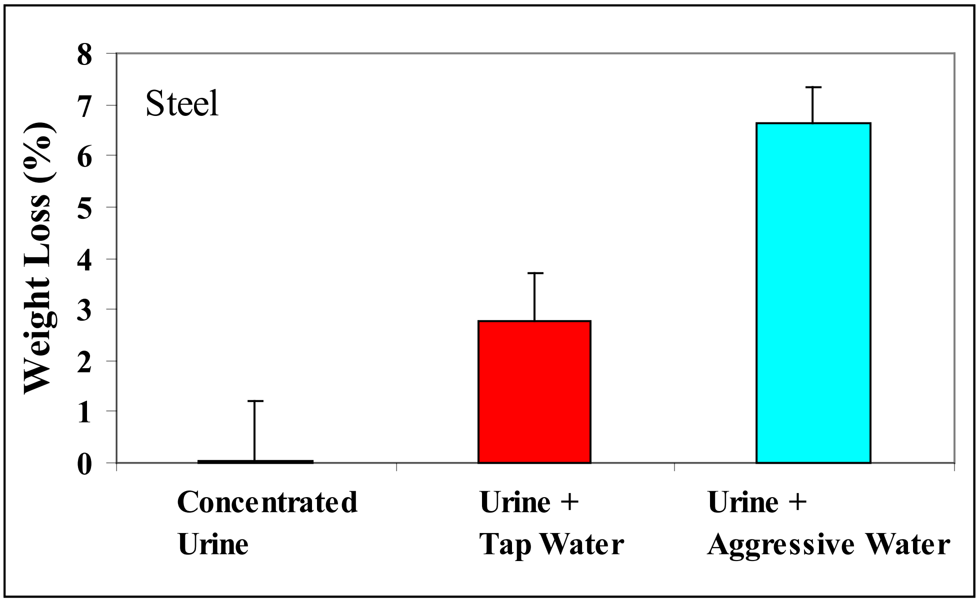

Figure 6. Steel weight loss in indicated solution.