Pilot Study Indicating Possible Effects on Water Impedance Characteristics from Stray Current

Kim Horsevad

[1]Horsevad Independent Technical Research & Analysis, Tryvej 96, DK-9750 Denmark

Abstract: ***Water subjected to stray current exhibit altered impedance characteristics in the frequency span between 10MHz and 4GHz, viewed in comparison with unexposed water from same source.***

Keywords: Water, Stray Current, Impedance, Vector Network Analyzer

1. Introduction

During an ongoing investigation of stray currents at a pig farm in the northern part of Denmark it was observed that the pigs reacted differently to water from different sources.

Chemical analysis of water samples from the different sources revealed no significant difference capable of producing the very distinct difference observed in animal behavior.

As a significant stray current (about 1,5V DC / 1,6 mA DC) can be measured between the water pipe and ground, it has been hypothesized that the stray current in some yet unknown way should be able to affect the water.

In order to test this hypothesis, water samples taken directly from the stopcock at the public water supply at the affected farm, and from a site as close as possible to the water company pumping station, were subjected to detailed analysis in a vector network analyzer.

No reports of similar research can be located, so as far as known this might be the the first report of stray current affected water analyzed with a vector network analyzer.

2. Literature Survey

Specific reports concerning the analysis of electrical network parameters for water affected by stray current cannot be located either through bibliographical databases or through even extensive searches on the Internet. As such, the present study might represent a novel idea for such analysis.

There are, however, a number of interesting reports on the subject of low-level electromagnetic, electric or magnetic effects on water.

It has been was demonstrated [1] that microwave exposure in non-thermal levels accelerates the diffusion process. Microwaves and stray current are, of course, radically different with regards to both field type, propagation medium and frequency, but the result nevertheless demonstrates that electromagnetic exposure at very low energy levels can produce macroscopically measurable effects om water.

A more detailed analysis, based on computer simulations, involving a greater number of parameters was published in 2004 [2], demonstrating that relatively weak DC fields decreased re-oriental and structural relaxation times significantly.

This result is quite interesting in relation to the present study, as the stray current measured at the affected site primarily is DC-based. It is possible, but not substantiable by the parameters analyzed in the present study, that the changes calculated by Vegiri could influence the impedance characteristics measured in the present study.

Extremely low frequency electromagnetic fields (ELF), which are also present in the observed stray current, has been shown [3] to affect the dielectric constant for treated water in the frequency span between 1-10GHz.

Magnetic fields has been shown to increase the hydrogen bond strength in water [4].

It has even been found that electromagnetically treated water affect the growth rate of biological organisms [5].

An interesting theory for the fundamental mechanism on such interaction between water and electric, magnetic and electromagnetic fields, namely the "Larmor precession hypothesis", has been set forth [6].

Larmor precession is the precessional change in the rotational axis of a rotating charged particle. The Larmor frequency is determined by the time in which a full rotation around the axis of the precessional circle takes place.

As such it has been proposed that magnetically induced changes in the Larmor precession might be responsible for a wide range of effects:

"Larmor precession of water molecules may also be a generalized transduction mechanism for weak MF effects on all aqueous interactions by altering the physiochemical properties of aqueous solutions, which in turn may modulate biological responses" [7, p220]

The coherent effect on charged particles projected by the magnetic field on the precessional rate is superimposed on the thermal fluctuations present in the material. As such, very little energy [8] is required to transduce weak magnetic field to physiochemical properties (and therefore subsequently reaction kinetics) of the affected water.

3. Problem Definition

The aim of the present study is to explore the possibility that stray current in some yet unknown way can affect water, and thereby cause observable changes in animal behavior when drinking.

As no reports of similar studies can be located even through quite extensive search efforts, the present study is conducted as a small scale pilot study, both in order to evaluate the experiment design and to evaluate whether the utilized test equipment is sensitive enough to facilitate the required analysis.

4. Methodology / Approach

Water from two sampling sites was subjected to detailed analysis in a parallel plate capacitor test fixture coupled to a vector network analyzer (VNA). First sampling site was located as close as possible to the water company pumping station. This sample is used as a reference. Second sampling site was the stopcock on the water pipe entering the farm.

The analysis is done with a parallel plate capacitor test fixture (2 aluminum plates, each 80mm x 20mm, separated by 1mm) covered with 150ml water and connected to a vector network analyzer

The vector network analyzer measures all relevant parameters for an electrical network. For this study the following parameters were subjected to further statistical analysis:

1) S_{12} Phase (°)
2) S_{12} Resistance (Ω)
3) S_{12} Reactance (Ω)
4) S_{12} Impedance (Ω)
5) S_{12} Conductance (S)
6) S_{21} Phase (°)
7) S_{21} Resistance (Ω)
8) S_{21} Reactance (Ω)
9) S_{21} Impedance (Ω)
10) S_{21} Conductance (S)

S-parameters are used in electrical engineering and antenna theory to measure and describe the input-output ratio between different terminals in an electrical network (system).

S_{12} represents measurements done on signals transmitted from port 2 to port 1. Conversely, S_{21} signifies measurements done on signals transmitted from port 1 to port 2.

In the present study measurements were done with a 10000 point scan between 10MHz and 4GHz.

Both samples were subjected to 10 full scans each. The results was averaged and further subjected to statistical analysis using a two-tailed paired t-test.

To ensure temperature stability of the test fixture and the sampled water temperature was thermostatically controlled to 17.5 degrees Celsius.

The parallel plate capacitor measuring fixture was located in a 2mm thick aluminum casing, ensuring a measured minimum 60dB electromagnetic shielding in the frequency span utilized in the analysis.

To safeguard against possible confounders all measuring equipment (consisting of vector network analyzer, test fixture and data-logging computer) was operated in a Faraday cage and both electromagnetic, AC magnetic and AC electric fields was monitored during the experiment.

No electromagnetic signals in the 100MHz to 8GHz range with a peak intensity over 6mV/m was registered while the experiment was running.

Ambient AC magnetic fields was below 0.01uT in the vicinity of the parallel plate capacitor test fixture. Ambient AC electrical fields was below 5V/m in the vicinity of the parallel plate capacitor test fixture.

Ethical approval: Although the primary reason for the implementation of this study is related to behavioral and pathophysiological changes observed in the livestock at the farm affected by stray current, no direct experiments has been performed on the animals. The conducted research is therefore not related to either human or animals use.

5. Results and Discussion

Chemical composition

As part of the ongoing investigation of the stray current problem water at the two sampling sites has earlier been tested for anomalous chemical composition. No significant changes between water sampled at the two sites could be measured.

Results from the VNA analysis

Both Phase difference, Resistance, Reactance, Impedance and Conductance were measured for both S21 and S12. Statistical T-test analysis of the results shows that the difference in impedance characteristics between reference water and water affected by stray current is remarkable significant for both S21 and S12. Phase difference between the samples is significantly different in S21 measurements, but not in S12 measurements.

Table 1: T-Test (paired, two-tailed) p-values

Parameter	S_{21}	S_{12}
Phase	0.0008 (*)	0.6208
Resistance	0.2015	0.3905
Reactance	0.9911	0.0742
Impedance	$2.31\cdot10^{-13}$ (*)	$2.38\cdot10^{-52}$ (*)
Conductance	0.2015	0.3905

(*) denotes differences significant at α=0.05

6. Limitations

No reports of any documented correlation between water impedance characteristic and possible effects on biological systems can be located, but as referenced earlier, a number of possible explanations of such connection could be hypothesized. The changed impedance characteristic would, in such a hypothesis, not by itself be responsible for any biological effects, rather would the difference in impedance characteristic be a macroscopically measurable parameter of an effect conferred on the water at microscopical scale.

As only two sampling sites were utilized in this small-scale pilot study, it can only be indicated, but not proven, that the stray current present in the area is the fundamental reason for the observed change in impedance characteristic. If a larger number of sampling sites had been employed, and if the data from such an more elaborate experiment would show a gradient of change in impedance characteristic correlating to a similar change in stray current it could be considered a quite robust result.

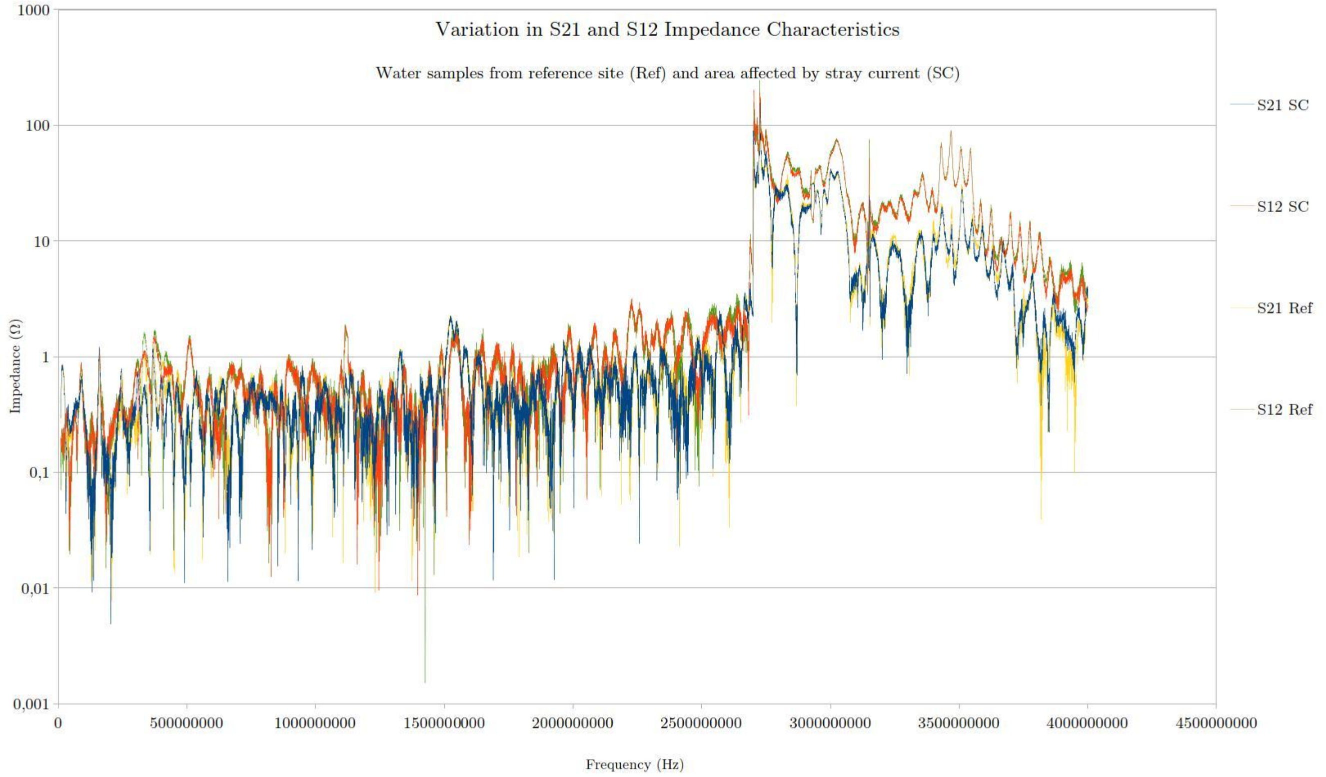

Figure 1: Variation in S21 and S12 impedance characteristic for the two water samples, measured with 10000 sampling points between 10MHz and 4GHz. Each dataset is averaged from 10 measurement series.

7. Conclusion

The measurement setup and basic methodology developed for this study is, primarily on the basis of the statistical quite significant results, considered explored sufficiently to be accepted as a reference point in the planning and design of subsequent more elaborate studies.

Although this study demonstrates, with remarkable statistical significance, that the impedance characteristics for the two analyzed water samples differs considerably, it should be noted, however, that the methodology applied in this small scale study does not provide any robust evidence for establishing a causal relationship between neither the stray current and the changed impedance characteristics nor between the observed behavioral and pathophysiological changes observed in the livestock and the changed impedance characteristics

Conflict of interest

The author state no conflict of interests. The author received no external funding for the study.

8. Future Scope

Further studies are needed, and a more in-depth detailed analysis is in the planning stages.

By analyzing a number of water samples taken at various point along the water supply route it should be possible to establish a gradient for the measured changes in impedance characteristics. If this gradient could be correlated to measurements of stray current in the affected area it would signify a quite robust causal connection between the two parameters.

By analyzing water samples taken from different sites affected by stray current it could be explored whether the observed changes in water impedance characteristics are widespread in areas affected by stray current.

A more detailed analysis of the animal reaction could be conceived. If a sufficiently large quantity of water is sampled along the sampling sites suggested in above paragraph, subsequently is fed to animals, which reactions are recorded on video, more robust analysis of the possible link between the observed behavioral and pathophysiological changes and the affected water parameters could be developed.

References

[1] Hinrikus H, Lass J, Karai D, Pilt K, Bachmann M. 2015. "Microwave effect on diffusion: a possible mechanism for non-thermal effect." Electromagn Biol Med. 2015;34(4):327-33.
[2] Vegiri A. "Reorientational relaxation and rotational–translational coupling in water clusters in a d.c. external electric field." Journal of Molecular Liquids. 2005:110(1-3):155-168
[3] Shen X. "Increased dielectric constant in the water treated by extremely low frequency electromagnetic field and its possible biological implication." J. Phys. Conf. Ser. 2011;329
[4] Hosada H, Mori H, Sogoshi N, Nagasawa A, Nakabayashi S. "Refractive indices of water and aqueous electrolyte solutions under high magnetic fields." J Phys Chem A 2004;108:1461–4.
[5] Goldsworthy A., Whitney H., Morris E. "Biological effects of physically conditioned water." Water Res. 1999;33:1618–1626.
[6] Pilla AA. "Weak time-varying and static magnetic fields: from mechanisms to therapeutic applications." In: Stavroulakis P, editor. Biological effects of electromagnetic fields: mechanisms, modeling, biological effects, therapeutic effects, international standards, exposure criteria. Berlin: Springer; 2003
[7] Funk RH, Monsees T, Ozkucur N. "Electromagnetic effects - From cell biology to medicine. " Prog Histochem Cytochem. 2009;43(4):177-264.
[8] Edmonds DT. "Larmor precession as a mechanism for the detection of static and alternating magnetic fields." Bioelectrochem Bioenerg 1993;30:3.

Author Profile

Kim Horsevad is the owner and chief technical analyst at Horsevad Independent technical Research & Analysis (www.horsevad.net). Current research focuses on developing measurement tools for quantifying interactions between electromagnetic fields and biological systems.