

# ***Interactive comment on “Discharge measurement with salt dilution method in irrigation canals: direct sampling and geophysical controls” by C. Comina et al.***

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Following reviewer requests the paper has been extensively modified. We attach a marked reviewed paper in order to allow for a direct verification of the implemented comments. We hope to have satisfied most of his observations which allowed to improve, in our opinion, the overall quality of the paper. Detailed answers to reviewer observations are provided in the following:

Reviewer #2:

General Comments The authors discuss an interesting and important problem: proper

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positioning of sampling points in channels. If the sampling points do not capture a representative section of the tracer plume, the experimental results are not valid. However, it is difficult to know a priori exactly where to take samples. Thus, typically, researchers take a single sample from the center of the channel or take multiple samples spaced at regular intervals across the channel. In both cases, study results can have significant, unknown error. It may be that this error could be reduced if a preliminary study is done and the plume visualized with the use of FERT. However, the study suffers from significant shortcomings. The FERT results and direct measurement results are significantly different and the difference is not adequately explained. The authors should consider conducting additional experiments in which the FERT measurements and direct measurements are both taken across the complete cross section. Alternatively, the FERT data from the current study should be reanalyzed to include only the data collected within the same cross sectional area as the direct measurements (ie 0.5m-1.5m from left bank). In either case, the authors should conduct additional experiments under different flow regimes in order to demonstrate the robustness of their conclusions.

A: We are glad that the reviewer underlines the importance of the topic we are dealing with and even if we are conscious that this study is sort of limited since only an experimental case history is presented we consider that it still include interesting suggestions. We do agree that the EC curves extracted from the two methodologies are different however, as we clearly stated in the abstract and in the text we do not think that FERT could be used at the moment for quantitative purposes but only as an imaging methodology, we can see from the presented results potentiality in that. Reducing the area of the canal in which a comparison of the two methodologies is made (as suggested 0.5m-1.5m from left bank) is what is partially reported in Figure 11 and indeed partially reduced the difference in the two curves even if not completely resolving the problem. We will prefer however to present the results of FERT test in the actual form (i.e. for the whole section) since this underlines important features of the test. We do agree with the general comment of the reviewer that the paper we are presenting is only a starting point both for the FERT technique and for the multisampling apparatus.

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We have performed some modification within the text in order to state it clearly. We however think that, even if limited, the application we are presenting is potentially interesting and not so common, as recognized by the reviewer himself, so it deserves publication.

#### Specific Comments:

**Abstract:** Flows in the natural environment are rarely laminar. What is Reynold's number in the canal? The last sentence of the abstract is an interesting concept, but the paper does not clearly discuss this issue in depth.

**A:** We have preliminary evaluated possible values of the Reynold's number given the natural variability of dimensions of the rectangular canal section and an average flow velocity. In most of our calculations the resulting Reynold's number was below 500 so in a almost "laminar" condition. We can partially agree with the reviewer however that the term laminar is sort of strong: indeed nearly all canals should be designed and operated at turbulent flow, according to Reynolds. However, as used by Reynolds, "turbulent" flow included everything above "glassy" flow, and it included also conditions found in most irrigation canals, with a low velocity and little vorticity. So we corrected the term with "sinuous", with the meaning proposed by Scobey (1939) ("a turbulent flow, according to Reynolds, but with a rather placid flow"). We have partially modified the last sentence of the abstract expressing what we can infer from the limited test results presented. Only from this result however it is already clear, as underlined by the reviewer himself, that a low conductivity zone of the section is not sampled and could have been if the direct verification had been performed.

**P10038, Line 6:** I don't see the need for multiple samples within a cross section if adequate mixing is truly known to exist. Perhaps the authors meant to say that multiple samples are needed if adequate mixing is not known to exist?

**A:** Yes we intended that... We have corrected the typo error in the text. Indeed adequate mixing is very difficult to be truly known.

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P10039, Line 9-10: In order to adequately evaluate the effect of monitoring point location in the evaluation of a non-uniform tracer cloud, I think you need to perform multiple experiments with different tracer clouds and monitoring locations.

A: Yes, probably this is a too general statement that we do not have accomplished with the limited results presented. This was however our general idea when performing the test and the overall objective of our research. We have modified the text in order to reduce the strength of the statement.

P10039, Line 16: The phrase ‘: : contemporary water picking up.’ is not clear.

A: The phrase has been removed, better explanation of the water sampling mechanism has been added in the second part of the paper also in response to other reviewer observations.

P10040, Line 2: units for water level are missing.

A: Units have been added.

P10040, Line 21-23: In bullet point c, what criteria is used to determine if there is enough turbulence to achieve adequate mixing?

A: We have delineated in the bullet points the main specifications to be considered in performing this kind of tests. Clearly each of them is not always easy to be accomplished and general rules are difficult to be presented. We have chosen the injection point in correspondence to a wire that alters the natural flow of the canal and seems to increase its turbulence. No particular further verifications have been performed.

P10040, Line 25-27: In bullet point e, a discussion of why a short distance results in inaccurate accounting of the tracer would be helpful.

A: This is manly related to the lateral mixing of the tracer in the measuring section which results more complicated than the vertical mixing. This aspect has been briefly discussed in the introduction with reference to literature works. We would prefer to not

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stress to much these general points and leave more room for the discussion of the tests. Indeed, there are no clear rules to address all of these point that often fight with logistical issues therefore our idea is that the FERT imaging can be an aid in similar conditions to evaluate whether the tests performed could or not be reliable.

P10042, Line 21-23 and P10045, Line 16-17: Does the sampling apparatus collect and composite all 9 samples resulting in one data point at each sample interval? or were the samples analyzed independently resulting in 9 data points at each sample interval?

A: The first of the two is true. We have tried to better explain the used methodology.

P10042, Line24-28: What is the effect of having only sampled part of the cross section? I don't see any values of EC reported in the paper.

A: The effect of the location of the sampling grid is discussed in the rest of the paper and also mentioned by the reviewer itself in respect to the area in which the sampling grid is positioned (see the first comment). Data of this sampling system are reported in Figure 6 being transformed in ER ( $1/EC$ ) to be compared with FERT measurements. We would prefer to maintain the figures in their actual form, however if the reviewer consider this point mandatory we could add a new figure presenting the same curve in term of EC (that would be simply symmetrical of Figure 6).

P10045, Line 6-8: If laminar flow existed in the canal, the leading edge of the plume would be expected to arrive sooner in the center of the channel and later along the edges. The leading edge appears relatively uniform and in fact the plume arrives slightly early along the side of the canal. This suggest that turbulence exists such that mixing is fairly uniform. The trailing edge may suggest laminar flow, but may also suggest storage in dead zones along the canal edge.

A: We have already partially discussed the condition we consider for the canal flow in the previous answer. In this respect we can moreover say that no dead zones are present within the canal reach so that the trailing edges may be indeed related to a

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variation in velocity along the banks. This part of the text has been deeply corrected and discussed with more detail.

P10045, Line 9: What is meant by the 'coda' of the plume?

A: Sorry, this was an earthquake derived term (indicating aftershocks after the "passage" of the main tremor) that we thought could be applied also to this out of topic experiment for describing the passage of the plume after the main peak. We have changed it.

P10045, Line 21-24: The mean FERT data is much lower than the direct measurements and it is not likely the sampling interval can explain this discrepancy. Additional experiments should be conducted or the direct measurement data should be analyzed at a 30 s interval in order to better understand the influence that sampling interval has.

A: Changing the sampling time of direct measurements to 30 s will indeed probably reduce the entity of the main peak if the appropriate sampling point is not located in its correspondence (actually few samples give the maximum concentration value). However reducing the sampling time is to our opinion not the correct strategy in the aim of a reliable measurement. The main point to be instead underlined with FERT measurements is that it takes "all" the 30 s interval to reconstruct an image not only is a lower sampling rate. In this way the measuring sequence start to evaluate potential differences among quadrupoles located in different positions along the section and obtains an "average" measure within the sampling time. This point has been better specified in the text.

P10045, Line 25-P10046 Line 3: The inversion algorithm should be checked very carefully. If the inversion algorithm did indeed induce this level of error, it suggests that FERT is not appropriate for this type of work.

A: As we clearly stated in the text we do agree that FERT is not appropriate at the moment to allow for a reliable quantitative estimation. However we still believe that

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the imaging of the plume is quite an interesting result and is valuable for a preliminary an more accurate location of sampling points. Issues related to smoothed or sharp inversion are common of any inversion code and it is not always simple to find the best compromise.

P10046, Line 4-10: The conclusions here seem a bit too strong. Isn't it just as likely that the direct measurement missed most of the low concentration area of the canal along the left side and right side? A better comparison would be the direct measurement data compared to the FERT data collected with the canal from 0.5 m from left bank to 1.5 m from left bank (the area actually sampled by the direct measurement technique).

A: A direct comparison has been attempted in the same sampled area as briefly presented in Fig. 11. Indeed in this area the two estimates are a little closer (due to the absence of the low concentration area in the FERT image) but all the other evidenced problems are not completely solved. However we would like to present the overall image since it is more related to the actual condition of the canal and more realistic of the whole test disposition.

P10046, Line 14-15: This appears to be a bit of an overstatement. Of the 9 sample points, 2 are clearly in low concentration areas, 2 (or 3) others are in areas with moderate concentration. It is not obvious that the sample points used would yield an average concentration 2-3 times the value obtained using FERT.

A: Indeed this is only one of the possible explanation of the difference and most probably not the only one. Adding together the presented motivations, all acting in the same direction, would probably bring to the presented difference. Some more comments have been added in the text.

Figure 3: It would be helpful to show the regression equation and  $r^2$  value.

A: Regression equation and  $r^2$  value have been added to the figure.

Figure 6: While the resistivity data is useful for comparison to the FERT data, it would

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be helpful to show the actual measured EC/NaCl breakthrough curve.

A: The presented curve is indeed the actually measured breakthrough curve simply transformed in resistivity value. We do not see the utility of presenting two times the same curve as mentioned in the previous comment.

Figure 10: Legend indicates cross-flow ERT, caption indicated cross-flow FERT.

A: The legend has been corrected.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/10/C5924/2013/hessd-10-C5924-2013-supplement.pdf>

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 10035, 2013.

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