Interactive comment on "Grey water footprint reduction in irrigated crop production: effect of nitrogen application rate, nitrogen form, tillage practice and irrigation strategy" by Abebe D. Chukalla et al.

Reply to Ann-Perry Witmer

We thank Ann-Perry Witmer for the comments; below we give our reply.

Comment

This paper conforms to the literature regarding virtual water transfers, though it allows me to raise a continuing concern regarding the classification of grey water footprint (WF) as an absolute, given its abstract dependency on time and location. The modification of environmental regulations by a governmental unit can result in significant differences for embodiment of virtual grey water in an agricultural product, making global water movement tabulation chimerical. Noting this objection, we proceed with review of the paper and its findings.

I'm uncomfortable with evaluating the WF in terms only of Nitrogen, since nitrogen-only inorganic fertilizers significantly affect soil pH. Phosphorus is prevalent in many inorganic fertilizers and in many locations is viewed to have a greater impact on receiving waters than N, thus governing grey WF. Incorporation of P into grey water analysis, or alternatively addressing pH imbalances in N-only fertilizers, could significantly alter the outcome of comparison between manufactured and organic fertilizer impact on WF, and this at least should be acknowledged in the paper.

Reply:

Grey WF of growing crop is an indicator of water pollution associated with crop production, it is expressed as the volume of water required to assimilate the pollutant load to meet agreed water quality standards (Hoekstra et al., 2011). If there is modification of environmental regulations by a governmental unit that may change the maximum acceptable concentration of the pollutant load to surface water and groundwater, the calculated volume of grey WF can alter; therefore it is recommended to report the grey WF values with the standards, also with spatial and temporal explicit.

We agree with the referee's concern on the importance of including the grey WF estimation associated with phosphorus (P) as well, particularly in areas where P is a serious threat to the quality of receiving water. In our study we simulate fertilizer application that has not only nitrogen but also nutrients such as phosphorus (P) and potassium (K). While the N-application rates is varying, we always keep P-application rates optimal, that is why we focus presenting the effects of management practices on N-related grey WF.

The grey WF of growing crop associated with the nutrients in fertilizer such as phosphorus, and nitrogen can be estimated, and by definition the nutrient load that requires larger volume of water to assimilate its pollutant load (thus governing grey WF) is reported. In the revised manuscript, we will acknowledge the need to incorporate the P-related grey WF analysis, which will give the overall N-related and P-related grey WF of fertilizer application.

Comment

Line 276 – knowing the complexity of Penman-Monteith calculations and the parameters associated with the equation, I'd want to look more closely at data before accepting reference ET calculation for this evaluation.

Reply:

We apply Penman-Monteith to calculate the reference ET. As input, we use daily climatic data such as precipitation, minimum temperature and maximum temperature extracted from the European Climate

Assessment and Dataset (Klein Tank et al., 2002). In addition we use monthly average climatic data such as solar radiation, relative humidity and wind speed from the FAO CLIMAWAT database (Smith, 1993). The average monthly values of the input climatic data (minimum and maximum temperature, precipitation, solar radiation, relative humidity, wind speed) and the calculated reference ET will be incorporated in a table in the Appendix of the revised manuscript.

Comment

Line 283 – use of zero pest stress impact seems odd for this evaluation. If zero-stress conditions are used, it would make sense to conduct at least a handful of scenarios with high-stress conditions to evaluate the variability of impact based on more extreme ambient states.

Reply:

The zero-stress in line 283 is meant for stresses related to weed, pest and diseases in affecting crop growth. Otherwise the effect on crop growth due to other stresses such as stresses from both excess and limitation of water, from limitation of nitrogen, and from very high or very low temperature are simulated.

Comment

Discussion/Conclusion

– It would be helpful to identify and analyse optimal conditions in terms of balancing grey WF and yield. Can you determine the conditions that generate the best outcome, evaluate them in APEX, and provide data to confirm?

Reply:

As it is shown in Table 2 in the manuscript, given the management practices considered the grey WF and crop yield are best at different N-application rates: grey WF is best (the smallest) at 50 kg N ha^{-1} y^{-1} when yield is not best (small), and crop yield is best (maximum) at 200 kg N ha^{-1} y^{-1} when the grey WF is large. Though the trade-off between improving crop yield and improving grey WF is apparent, the authors share the referees speculation that there would be a conditions that generate optimal for both grey WF and crop yield; exploring these conditions in the study has setbacks mainly from the management options in the model, also this is beyond the scope of the current study.

References:

Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., and Mekonnen, M. M.: The Water Footprint Assessment Manual: Setting the Global Standard, Earthscan, London, UK, 2011.

Klein Tank, A., Wijngaard, J., Können, G., Böhm, R., Demarée, G., Gocheva, A., Mileta, M., Pashiardis, S., Hejkrlik, L., and Kern-Hansen, C.: Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment, International journal of climatology, 22, 1441-1453, 2002.

Smith, M.: CLIMWAT for CROPWAT. A climatic database for irrigation planning and management, FAO, 1993.