The Application of the Models for Design of Wetlands

The models of the constructed wetland can be used to design constructed wetlands, provided that they are of the same type as erected at the University of Dar es Salaam, and constructed in the tropical region. The constructed wetland at Dar es Salaam University is based on the application of gravel to ensure that it is not clogged due to suspended matter. It is under all circumstances a good idea to have either WSP in front of a constructed wetland or some kind of sedimentation. As for the plant species applied, it has not yet been possible to observe any difference in efficiency.

It is possible to design a constructed wetland by two methods – both methods using the models to ensure that the right efficiency is applied. It is presumed that the following is the basis for the design: 1) The flow rate 2) the concentration in the inflowing water of the components that are supposed to be reduced by the wetland with a given efficiency 3) the required efficiency for total nitrogen, nitrate-nitrogen, ammonium-N, E. coli and/or BOD_5.

Method 1

Use the design equations given in the text for constructed wetlands; see 3.8.1 and/ or 3.8.2. The models are based on the CW at Dar es Salaam University, where the area is about 35 m^2. It is assumed that a CW with the area A m^2 will give the same efficiency as the CW at Dar es Salaam University, if the ratio of flow rates is A/ 35. Therefore, the flow rate to be used in the models is 35Q / A, where Q is the flow rate for the CW under design. Consequently, the nitrogen model should be applied (model N^2 is probably most easy to use) at a flow rate 35Q /A, and the concentrations corresponding to the inflowing water. The model is not giving the E.coli efficiency, which implies that the design equation has to be used. On the other hand, E.coli is usually not the limiting factor for the constructed wetland technology. The BOD_5 is given indirectly. It has been verified by several analyses but not by as many observations as used for the nitrogen model, that BOD_5 removal follows organic nitrogen removal. It means that the organic nitrogen removal should by multiplied by 14 to give the corresponding removal of organic matter, which has to be multiplied by 1.38 to yield the removal of organic matter expressed in oxygen demand. Therefore a multiplication by 19.3 of the removal of organic nitrogen in mg/l gives the BOD_5 removal in mg/l. The other concentrations should be in accordance with the know analyses of the incoming water. If the organic nitrogen is different from BOD_5 / about 19.3 two runs could give the total results, one with organic nitrogen = BOD_5 / 19.3 and one with the actual concentration of organic nitrogen. If the results are not in accordance with the design equations, the model can be used to try higher or lower flow rates and select the flow rates that give the required efficiencies. It is recommended to use either the average of the two flow rates or to use the model results as there are usually more reliable, provided as emphasized above that the type of CW is the same as the type on which the model is based.

Phosphorus removal and heavy metal removal can be found from the phosphorus model and the heavy metal removal. Notice, that these removal efficiencies are quite low, because P and heavy metals can only be removed by adsorption and plant uptake. It implies that in the long run when the adsorption capacity has been used up, will the only removal be the P and heavy metals that are removed by harvested plants. Notice that removal of organic matter (BOD_5) by decomposition processes implies that phosphorus that is 0.5-1.0 % of the organic matter will be released correspondingly. Negative removal efficiency can therefore not be excluded. If, however, another soil type with much higher adsorption capacity for phosphorus and heavy metal is applied, it is possible to obtain much better removal efficiency.

<u>Method 2</u>

The N^2 model is used to find the right flow rate to obtain the nitrogen removal and the BOD_5 removal required. Various flow rates are tested until the right efficiency is obtained. The BOD_5 removal is found as for method 1 by multiplication of the removal of organic nitrogen by 19.3. If the ratio between organic nitrogen and BOD_5 is very different from 1: 19.3 the highest concentration of organic nitrogen (the actual concentration or the BOD5 / 19.3) should be applied. The model gives then the removal in mg/l for both BOD_5 and for organic nitrogen, which should be subtracted from the concentrations in the inflowing water to yield the concentrations in the treated water. When the required efficiency has been obtained the area required for the wetland under design is $35*Q_1 / Q_m$, where Q_1 is the flow rate for the CW under design, while Q_m is the flow rate giving the required efficiencies found by the model. When the model has been applied it is checked by the use of the design equations if the results of the model are in accordance with the design equations. If it is not the case, either the model results or the average of the two different results should be applied.

The phosphorus and heavy metals models are applied as indicated under method 1.