To the Editor:

In the work of "Unified Conceptual Approach to Targeting and Design of Water and Hydrogen Networks",[1] the authors extended an earlier developed nearest neighbor algorithm (NNA)[2] to resource conservation network (RCN) with interception placement. In particular, the technique is applied in two examples that involve the synthesis of water and hydrogen networks. The resulting networks achieve the minimum resource and waste flow rates identified in the targeting stage. The author has been using the algorithm quite satisfactory in many exercises.

The basic principle of NNA in its simplest form may be stated as: "*To satisfy a sink, the sources to be chosen are the nearest available neighbors to the sink in terms of its quality level*".[2] In other words, two sources that are having quality levels just higher and just lower than the sink are mixed to satisfy the flow rate and load requirements of the latter. The required amounts of the two neighbor sources are dictated by the material balance equations. If the required flow rate of a source is not sufficient, then the total flow rate of that source is used completely and the next neighbor source is considered to satisfy the sink. Steps for synthesizing a RCN using NNA are summarized as follows:[2]

1. Arrange the sinks and the sources (including fresh resource and regenerated sources) in an ascending order of quality level, respectively. Start the design process from candidates with highest quality level.
2. Match each sink with source(s) of the same quality level, if any are available.
3. Mix two sources i (with flow rate F_i and quality y_i), and $i+1$ (with flow rate F_{i+1} and quality y_{i+1}), to fulfill flow rate (F_j), and quality requirement (y_j) of sink j. Note that the two sources possess quality level of just lower and just higher that that of the sink, i.e., $y_i < y_j < y_{i+1}$. Note also that the available source candidates include the fresh resource (with flow rate F_F and quality y_F), as well as regenerated sources (with flow rate F_R and quality y_R), with their respective flow rates obtained in the targeting stage. The flow rate for each source is calculated via the mass balance Eqs. 1 and 2

$$F_{i,j} + F_{i+1,j} = F_j \quad (1)$$

$$F_{i,j}y_i + F_{i+1,j}y_{i+1} = F_j y_j \quad (2)$$

where $F_{i,\ j}$ is the flow rate sent from source i to sink j.

4. Unused source(s) will be discharged as waste.

However, for more complicated cases, following the principle of NNA alone is insufficient to synthesize a RCN that achieves the minimum flow rates. A better strategy is to incorporate the various insights obtained from the targeting stage into network design to ensure an optimum RCN is synthesized. In most cases, targeting will determine the minimum fresh resource and waste flowrates for the RCN. However, apart from the flowrate targets, other insights such as stream selection are also necessary. This has not been pointed out explicitly in previous work. However, this becomes a necessity for some complicated cases, as shown in the following example.

Total Water Network Example

This is the classical fixed load-based water minimization problem taken from Wang and Smith.[3] Limiting water data for the example is summarized in Table 1. For the network in reuse/recycle and regeneration schemes, the NNA has been demonstrated to be successfully used in synthesizing water networks that achieve the minimum flowrate targets (see ref. 2 for reuse/recycle, and ref. 4 for regeneration schemes). However, when a *total water network* is to be synthesized, using the NNA procedure[1,2] alone does not lead a network with minimum waste treatment flow rates. Hence, insights from the targeting stage should always be incorporated to synthesize a total water network that achieves the targets. This is illustrated as follow.

It is assumed that two interception units are used for regeneration and wastewater treatment, respectively, each with an outlet concentration (C_{out}) of 5 and 10 ppm, respectively. Besides, the environmental discharge limit is set at 20 ppm. Following the targeting procedure of the total water network,[5,6] the fresh water, wastewater, regenerated and treatment flow rates are determined as 20, 20, 73.68 and 17.79 t/h, respectively.[6] However, if we design the network using the NNA procedure[2] alone, the sequence of fulfilling the sinks with the sources are given as follow, i.e., SK1 (satisfied by fresh water, FW), SK2 (satisfied by SR1, SR2 and regenerated water, RW), SK3 (satisfied by RW and SR2), and SK4 (satisfied by SR2 and SR3). The reuse/recycle scheme between these sinks and sources are shown in Figure 1. After fulfilling the sink requirement, the leftover sources are SR2 (47.97 t/h), SR3 (35.71 t/h), and SR4 (10 t/h). At this end, the NNA procedure[2] does not propose any further guideline on the selection of sources for regeneration and wastewater treatment. Hence, one may end up sending the leftover flow rate of SR2 (47.97 t/h) and the remaining 25.71 t/h from SR3 for regeneration, since the regeneration is having lower outlet concentration than that of the wastewater treatment unit. Next, the leftover SR3 (10 t/h) and SR4 are sent for wastewater treatment. As shown in Figure 1, doing this lead to wastewater treatment flow rate of 19.75 t/h, i.e., higher than the targeted flow rate (17.79 t/h).

Table 1. Limiting Water Data for Example

Sink	Flow rate	Concentration
SK_j	F_j(t/h)	C_j (ppm)
1	20	0
2	100	50
3	40	50
4	10	400
$\sum_j F_j$	170	
Sources	Flow rate	Concentration
SRi	F_i(t/h)	C_i(ppm)
1	20	100
2	100	100
3	40	800
4	10	800
$\sum_i F_i$	170	

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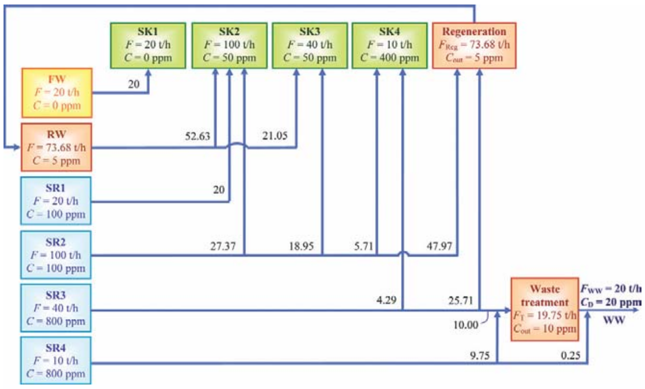

Figure 1. Network design with NNA (without insight from targeting).

[Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

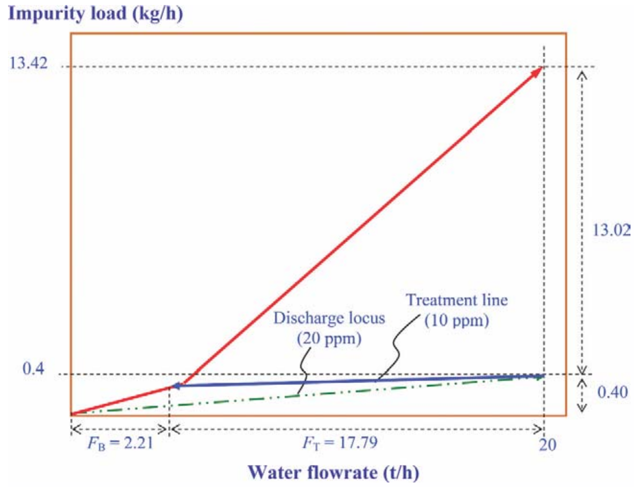

Figure 2. Targeting for minimum wastewater treatment flow rate.[10]

[Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

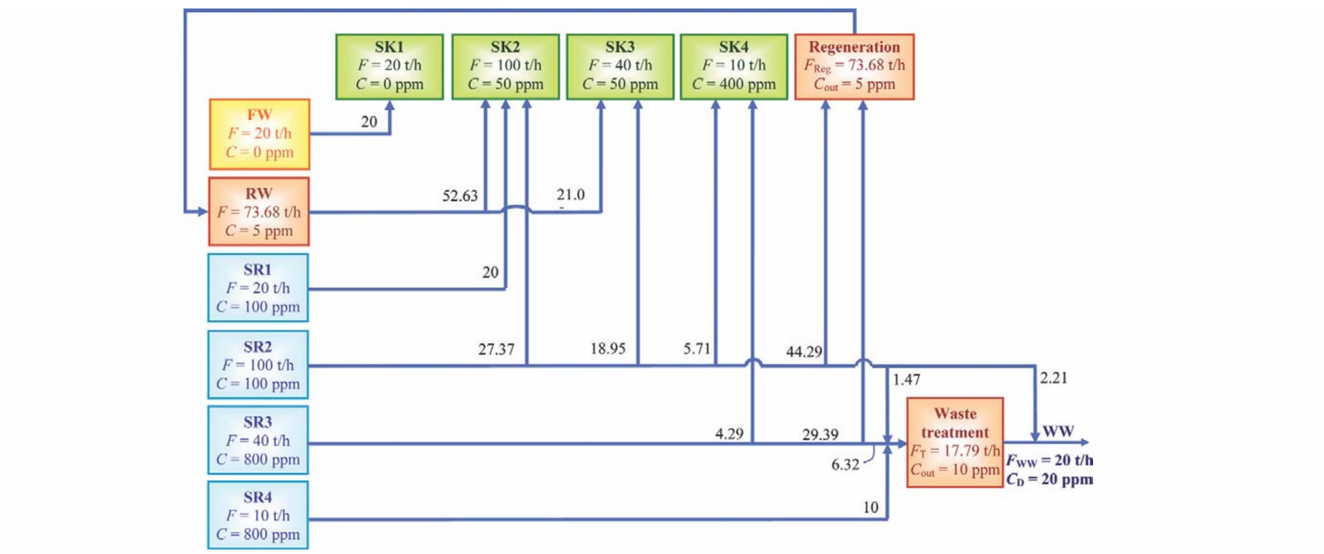

Figure 3. Network design that achieves the minimum flow rate targets.[10]

[Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

To overcome the problem, one should incorporate the insights from targeting in the design stage. With the total water network targeting procedure, it is determined that two wastewater streams are emitted from the network, i.e., 3.69 t/h at 100 ppm, and 16.32 t/h at 800 ppm (a total of 20 t/h of wastewater stream).[6] Hence, these wastewater streams should first be allocated to the wastewater treatment unit in the design, before the sources are being sent for regeneration. With these wastewater streams identified, one may easily determine that the minimum treatment (F_T), and bypass (F_B) flow rates as 17.79 and 2.21 t/h, respectively (see the wastewater targeting in Figure 2). The leftover source flow rates (after being allocated to sinks and wastewater treatment) are then sent for regeneration. The total water network that achieves the identified targets is shown in Figure 3. Note that the reuse/recycle flow rates between the sinks and sources remain the same as in Figure 1, while the streams that are sent for regeneration and wastewater treatment are having different flow rates.

Conclusion

In synthesizing a RCN, it is best to incorporate the various identified targets during the design stage. Doing this ensures the synthesized network to achieve the minimum flow rate targets identified earlier. This is demonstrated using the NNA in this Letter. The same principle should be used when other network design tools (e.g., source sink mapping diagram, water source diagram, etc.) are used. This has also been demonstrated previously in the synthesis of mass and heat exchanger networks.

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Dominic Chwan Yee Foo
Dept. of Chemical and
Environmental Engineering,
University of Nottingham Malaysia,
Broga Road, 43500 Semenyih
Selangor, Malaysia
E-mail: Dominic.Foo@nottingham.edu.my