GROUNDWATER
MAKING THE INVISIBLE VISIBLE

BALKANS JOINT CONFERENCE AND EXHIBITION
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SHUKOS | SHUKALB

COMPARISON OF TWO EFFLUENT DISINFECTION TANKS WITH DIFFERENT GEOMETRIC DESIGNS

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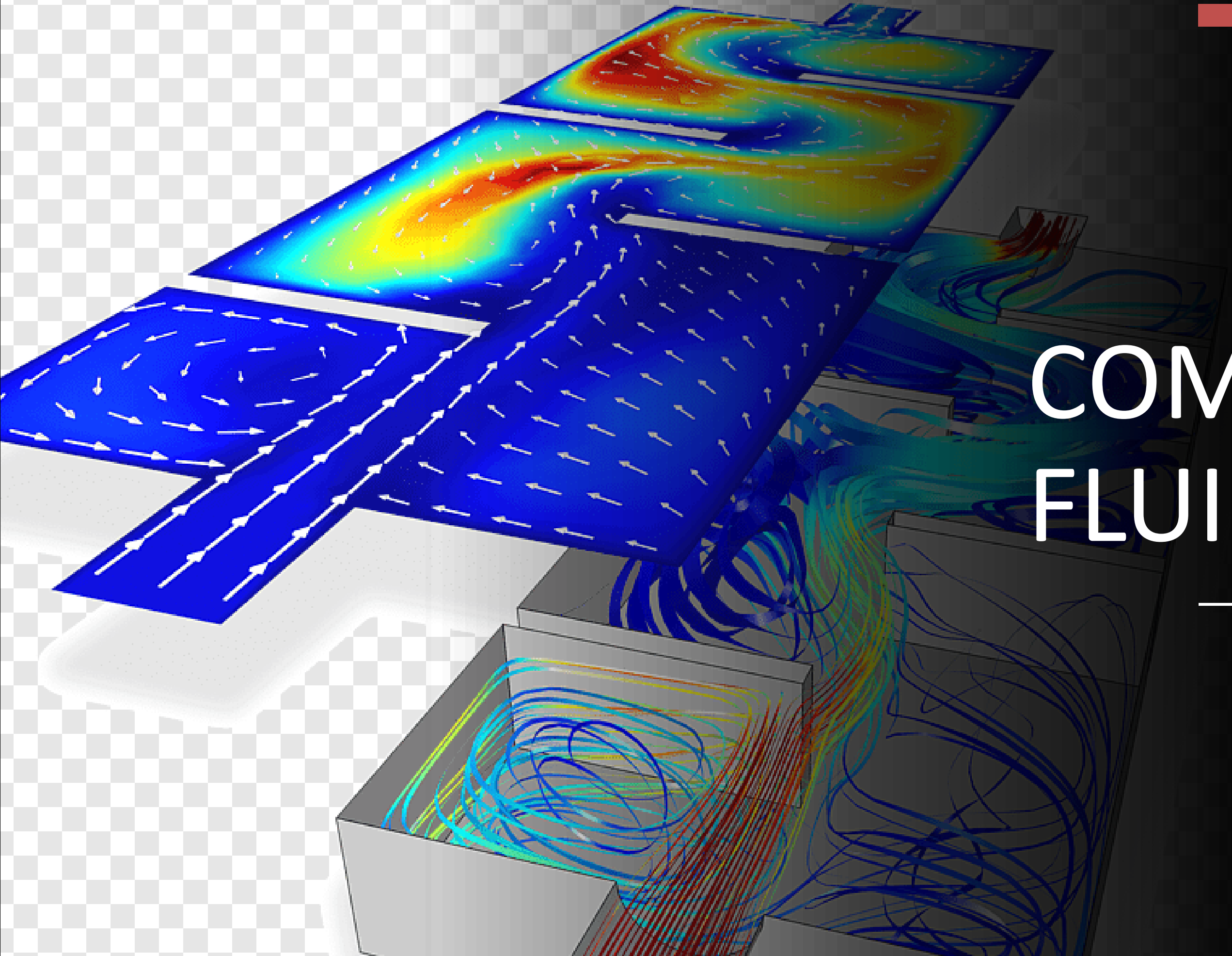
WASTE WATER TREATMENT

- Sludge Treatment
- Discharges of treated water into water bodies

CONTACT TANKS

- Contact tanks are critical infrastructure used in water treatment plants. Historically, the design of these facilities is not based on minimal energy consumption during tank contact operation.
- The hydraulic and mixing efficiency of contact tanks can be evaluated using indices that can be obtained from residence time distribution (RTD) and cumulative RTD quantities.



COMPUTATIONAL FLUID DYNAMICS

TANK GEOMETRIES

- The geometries of both models are modelled in CATIA V5.
- The mesh for first tank is kept simple consisting of 79,114 cells due to its simple geometry, for second model mesh is refined near the baffles and the inlet consisting of 1,930,055 cells due to its complex geometry.

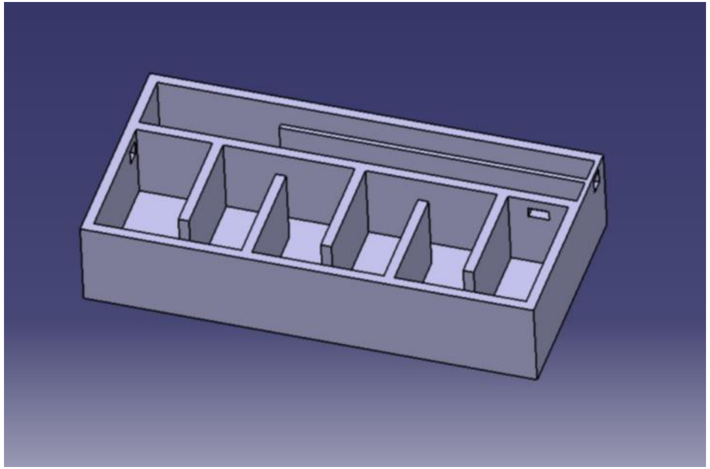


Figure 1. *Geometry of second contact tank.*

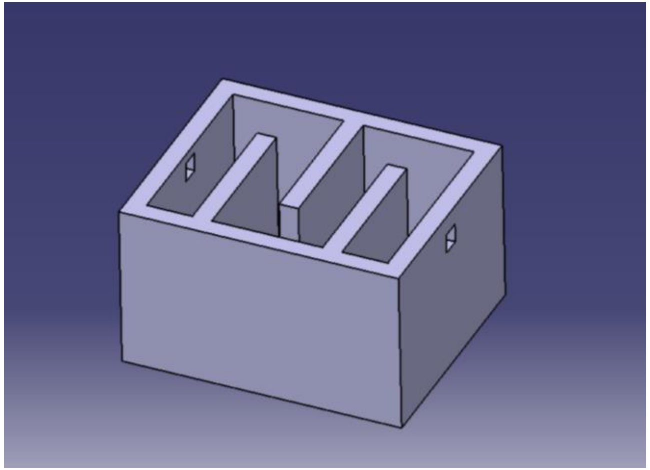


Figure 2. *Geometry of first contact tank.*

RESULTS

- Baffles are perpendicular to the inlet of the tank. When the flow enters it directly impacts the front wall, which causes an increase in static pressure, hence, overall pressure.
- As can be seen, a dark red color is present in front of the inlet, representing the area of high pressure, highlighted by a black box.
- From physics, the flow tends to move from high pressure to low pressure, which in this case causes the flow to reverse its direction back to the inlet. But as the flow is continuously entering the tank, it tends to create a recirculation zone, which as result, causes the formation of by-products.

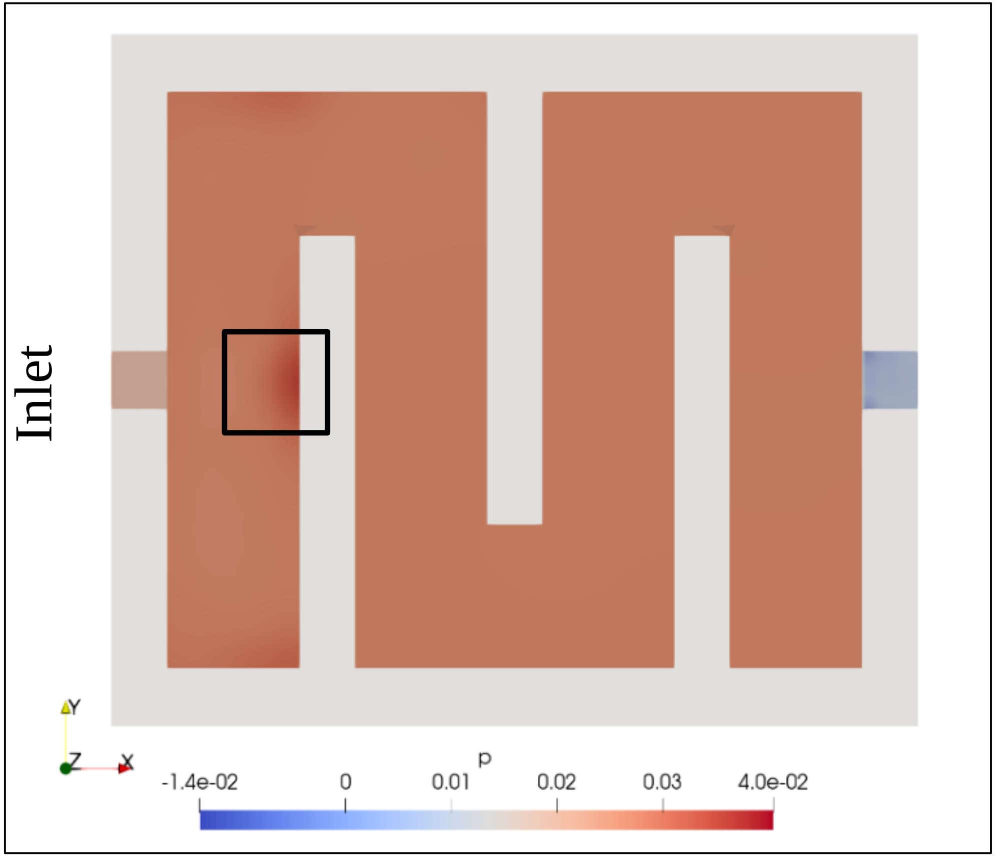


Figure 3. *Pressure contour of first contact tank.*

RESULTS

- The velocity distribution of the first tank justifies the phenomenon of sudden impact where the flow velocity tends to zero and the recirculation near the inlet.
- The increase in local pressure on the baffle, causes the flow to accelerate towards the low-pressure regime, the value of large velocity highlighted by a red box.
- These recirculation zones in the tank increase the contact time of disinfectant with a certain parcel of water, resulting in the formation of by-products which can cause hazardous problems. The low pressure at the outlet, cause to generate a current due to which disinfectant is unable to reach the corner, resulting in inefficient decontamination.

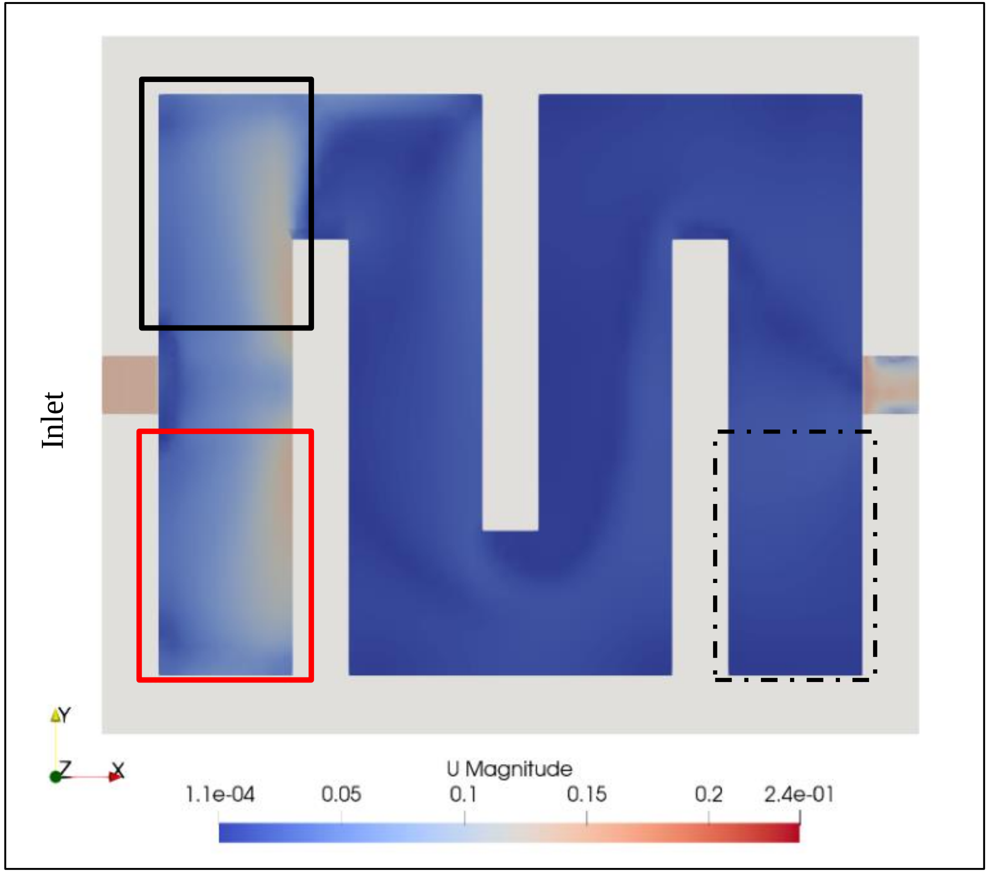


Figure 4. *Velocity contour of first contact tank.*

RESULTS

- The scalar distribution in the tank which represents the concentration of disinfectant, chlorine in this case.
- The red colour is the value of higher concentration while the blue shows the value of lower. It can be seen the concentration of disinfectant is lower in the highlighted area which supports our argument.

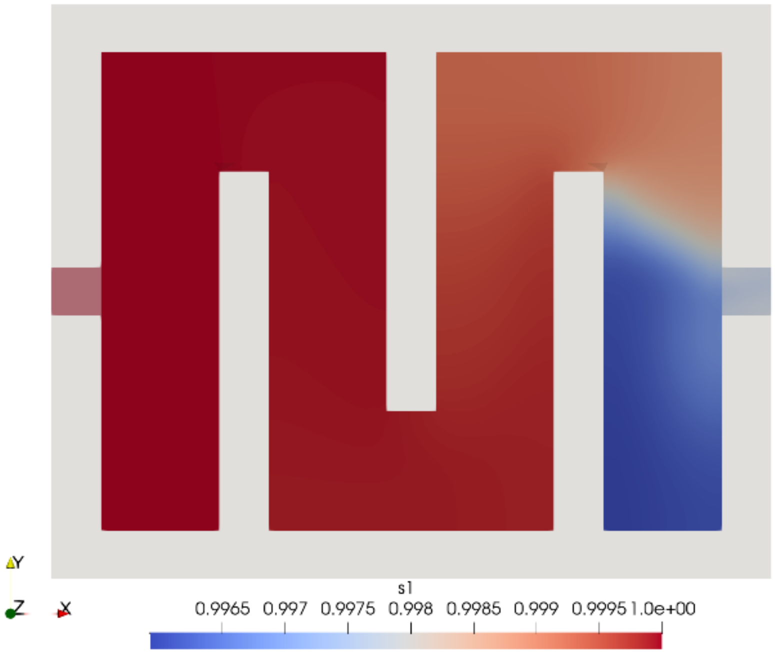


Figure 5. *Scalar transport contour at t_{10} for first contact tank.*

RESULTS

- We do not observe the same phenomenon as in contact tank 1.
- The baffles are parallel to the inlet which does not let the flow sudden stop and hence no localize pressure which result in streamlined flow.
- As the pressure is uniformly distributed, the number of recirculation zones will be a lot lesser than in the first tank. This will reduce the probability of by-product formation, hence efficient decontamination.

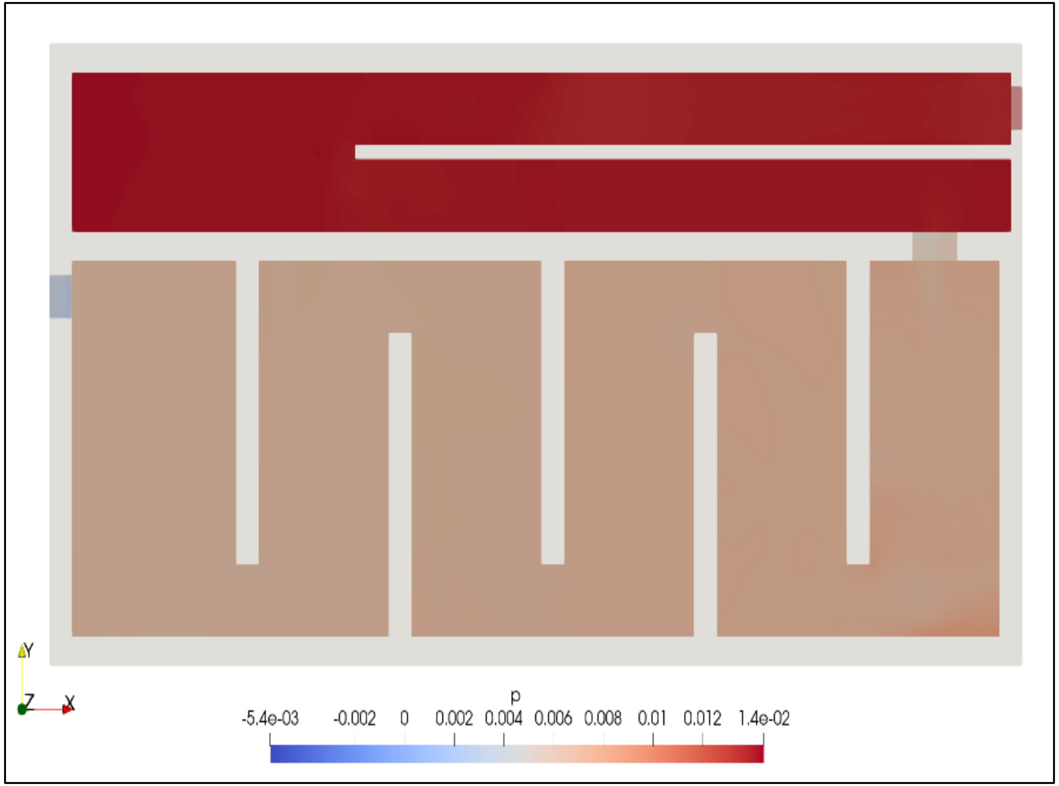


Figure 6. *Pressure contour of second contact tank.*

RESULTS

- The velocity distribution, shows that there exist some recirculation zones near the edge of each baffle, as the numbers of the baffle are greater this will have more recirculation near the edges, hence greater chances of by-products.
- As we can observe, in the black box, the water parcel has lower velocity here, hence the rate of contact between water and disinfectant due to convection will be lower, which is not essential. This same phenomenon can be observed in for contact tank 1.

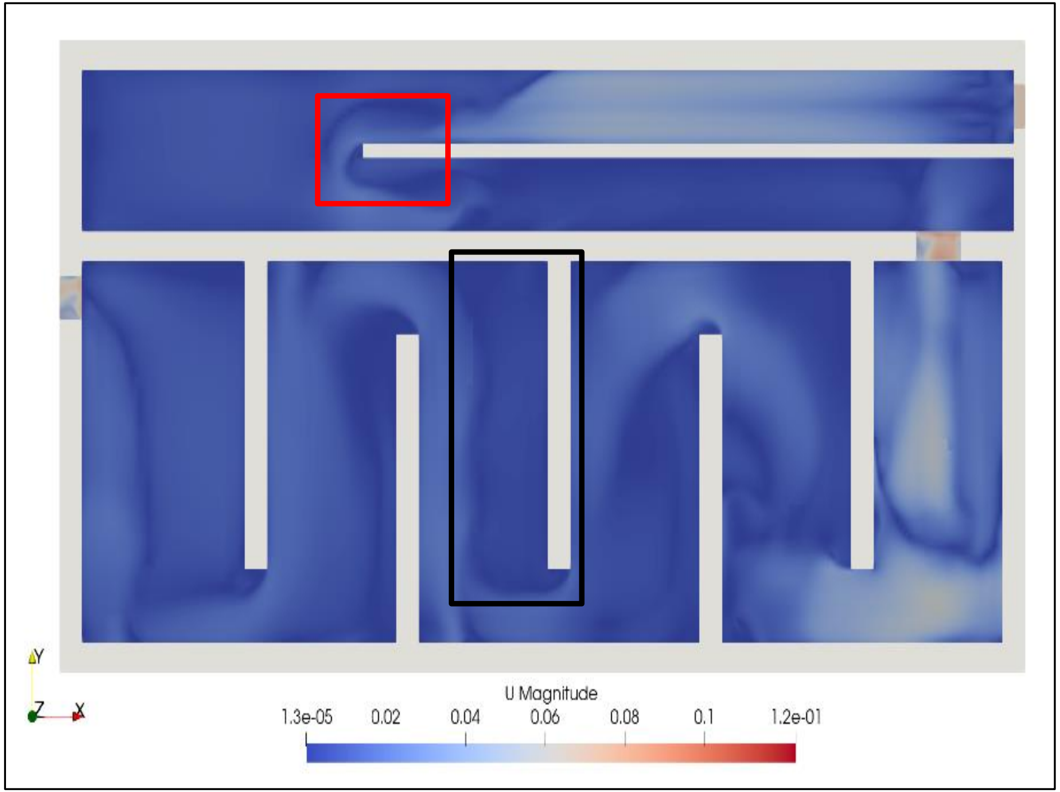


Figure 7. *Velocity contour of first contact tank.*

RESULTS

- As described earlier, there also exists the region behind the last baffle where the process of decontamination doesn't occur efficiently.

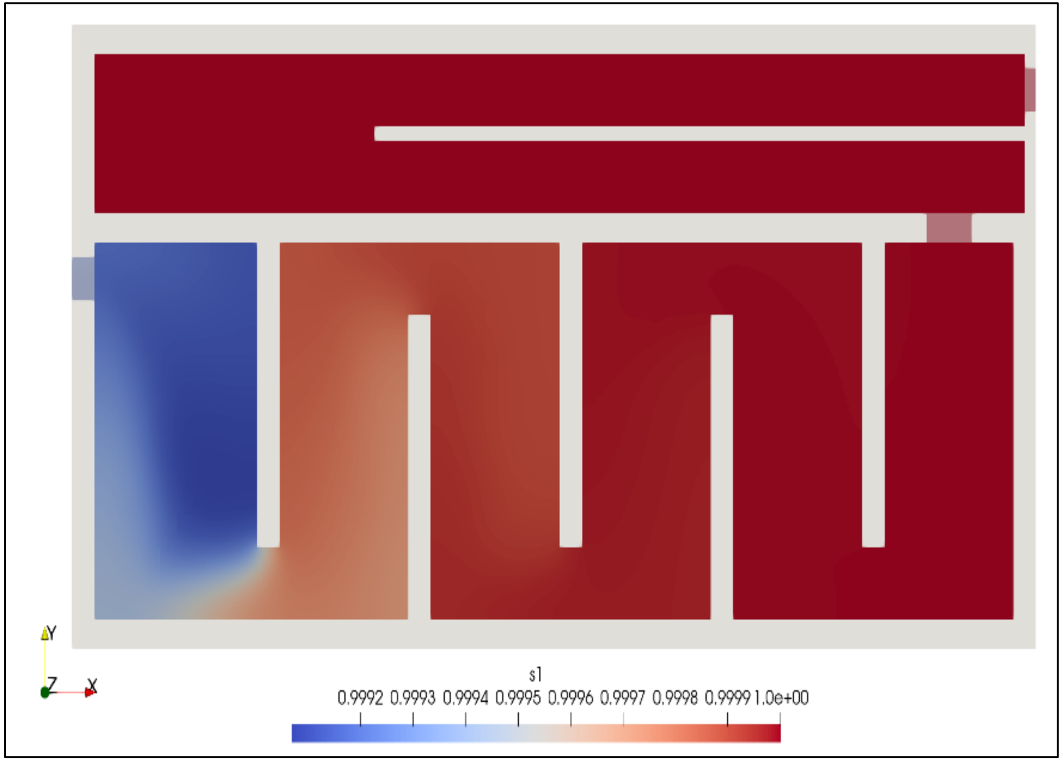


Figure 8. *Scalar transport contour at t_{10} for second contact tank.*

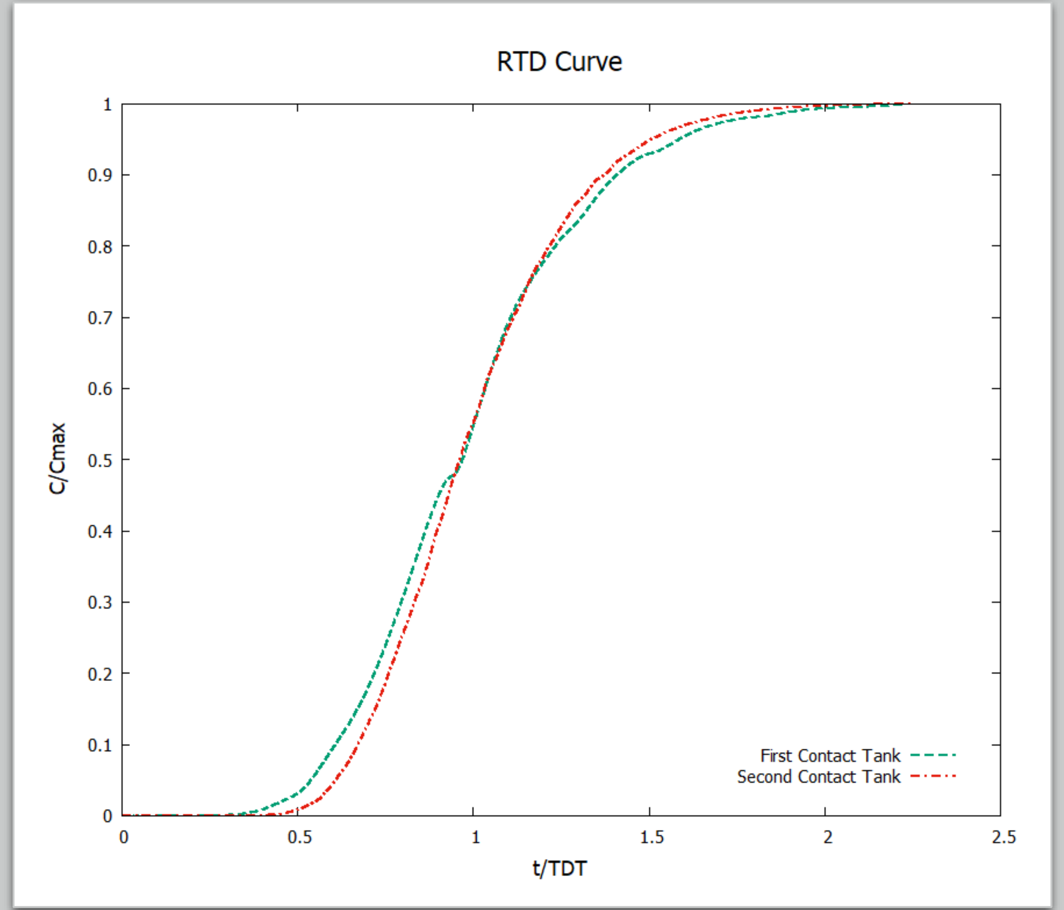


Figure 9. *Comparison of RTD curves of both tanks.*

RESULTS

- The tracer study we did is used to calculate these graphs. From the RTD curves for both tanks and BF, we found contact tank 2 to be more efficient than contact tank 1.
- The first reason is length to width ratio. However, with 66% increase in length-to-width ratio has caused only a 10.4% increase in baffle factor. That is because it is not a perfect plug flow.
- There exists turbulence, recirculation, inlet outlet conditions, boundary layer generation near the wall and internal flow dynamics which have a negative effect on efficiency and performance.
- Hence, the RTD curve and ratio of t_{10}/t_{90} can be an important indicator.

Tank Configuration	BF	MI	t_{10}/t_{90}
First Contact Tank	0.610	2.32	0.43
Second Contact Tank	0.674	2.01	0.49

- While observing the RTD curve we observe that contact tank 2 has a steeper gradient which reflects it closer to plug flow, furthermore, the value of t_{10}/t_{90} is lower than BF that's because BF gives an ideal plug flow condition which is not true in real-world problems.
- The value of MI shows there is less diffusion in the second tank which can only be justifiable once we observed the entire RTD curve. The higher number of baffles in the second tank tends to reduce the recirculation and diffusion process and enhance the contact time by better advection which leads toward plug flow.

SUGGESTIONS

- The inlet should be in line with the baffle as in contact tank 2, which will terminate the chances of localized pressure and recirculation near the inlet.
- The sharp edges and corners should be smoothened out which reduces the recirculation, hence the formation of by-products.
- There must be small slots to leak the flow through the baffle that will address the improper contact of disinfectant with the water parcel.
- The length-to-width ratio must be high which can increase the hydraulic efficiency.
- The spacing between the baffles must be reduced so that the flow remains confined between baffles which also reduces recirculation.

CONCLUSIONS

- In this study, the hydraulic efficiency of the contact tanks was evaluated using tracer studies.
- Calculation of performance parameters such as TDT, baffle factor, Morill index and the ratio of t_{10} to t_{90} were calculated for two different tanks. RTD curves were produced, which in turn were found to show the entire efficiency of the system.
- A step method for tracer initialization is used which shows more reliable data and the RTD curve can be plotted directly.
- The BF of the second tank shows over 10% of improvement over the first tank, but BF cannot evaluate the proper system dynamics by just considering the limb of the RTD curve. The ratio of t_{10} to t_{90} founds to be lower than BF because the entire curve considers flow and scalar transport dynamics.

THANK YOU!