**Water and Wastewater Treatment**

**Problems on Coagulation, Flocculation and Sedimentation**

1. Two sets of jar tests were conducted on raw water containing 15 turbidity units and an HCO3- alkalinity concentration of 50 mg/l expressed as CaCO3. Given the data below, find the optimal pH, coagulant dose, and the theoretical amount of alkalinity that would be consumed at the optimal dose.

# Jar test I

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **1** | **2** | **3** | **4** | **5** | **6** |
| PH | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 |
| Alum dose (mg/l) | 10 | 10 | 10 | 10 | 10 | 10 |
| Settled turbidity (TU) | 11 | 7 | 5.5 | 5.7 | 8 | 13 |

# Jar test II

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **1** | **2** | **3** | **4** | **5** | **6** |
| PH | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| Alum dose (mg/l) | 5 | 7 | 10 | 12 | 15 | 20 |
| Settled turbidity (TU) | 14 | 9.5 | 5 | 4.5 | 6 | 13 |

1. A coagulation and flocculation unit requires 30 mg/l of alum to treat water that has a natural alkalinity of 10 mg/l as CaCO3. Hydrated lime, Ca(OH)2, is also required to get a residual alkalinity of 15 mg/l as CaCO3. The design criteria for a rectangular flocculation basin are:

* detention time = 45 min,
* depth = 3.5 m,
* length to width ratio = 3:1,
* average velocity gradient = 60 s-1 and
* dynamic viscosity = 1 x 10-3 Pas-1.

The flocculation basin is followed by a sedimentation tank that removes flocs and 20 mg/l of suspended solids. If the design water flow is 8000 m3/d,

* 1. determine the length, width and power requirements of the flocculation basin

* 1. calculate the daily alum and lime requirements in Kg/d
  2. compute the total solid sludge produced in the sedimentation tank in Kg/d

what natural alkalinity (mg/l as CaCO3) avoids the need for lime to get the required residual alkalinity of 15 mg/l as CaCO3 for the same alum dosage?

1. A settling column analysis is performed on a dilute suspension of particles from a water. The suspension exhibited discrete particle settling characteristics. Data collected from samples taken at a depth of 1.5 m are as follows:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Time required to settle 1.5 m, min | 0.6 | 1.2 | 2.2 | 4.5 | 6.0 | 8.8 |
| Fraction of particles settled | 0.40 | 0.50 | 0.65 | 0.82 | 0.91 | 0.96 |

1. Plot the velocity distribution for the suspension
2. Find the overall removal if the surface loading rate of a clarifier is designed to be 2400 m3/m2.d.
3. A laboratory settling analysis has been performed on a suspension exhibiting flocculent (type II) sedimentation with the results given in the following table. The column had a diameter of 14 cm and total depth of 2.40 m, with sampling ports spaced every 0.60 m. The initial concentration of the suspension was 480 mg/l.

|  |  |  |  |
| --- | --- | --- | --- |
| Time, min | Suspended solids concentration, mg/l | | |
| Port 1 (60 cm) | Port 2 (120 cm) | Port 3 (180 cm) |
| 5  10  20  30  40  50  60  75 | 385  334  265  216  180  154  123  106 | 420  379  330  279  250  213  182  148 | 438  405  355  315  280  251  217  192 |

1. Prepare the following graphs
   1. Percentage SS removed versus time
   2. Isoremoval curves
   3. Total % removal versus detention time
   4. Total % removal versus surface overflow rate
2. Size a primary clarifier for 50 % removal based on the data in (a). The design flow rate is 4000 m3/d.
3. If the volumetric flow rate doubles but the concentration and settling characteristics of the suspended solids do not change, what is the expected total removal? What is the expected removal if the flow rate increases by 10%?
4. A sedimentation facility was designed to treat an average flow of 0.6 m3/s. The design overflow rate and the detention time are 45 m3/m2-d and 2.5 h, respectively. The length-to-width ratio of the rectangular basin is 4.3-to-1. Calculate the dimensions of each basin if two, three, or four basins are provided. Also, compute the weir loading rate in each case, if one weir trough and single weir plate is provided along the width of each basin. The outlet channel is 1 m wide.