CHAPTER ONE

INTRODUCTION

EFFICIENCY AND SUSTAINABILITY CONSIDERATIONS IN WASTEWATER TREATMENT

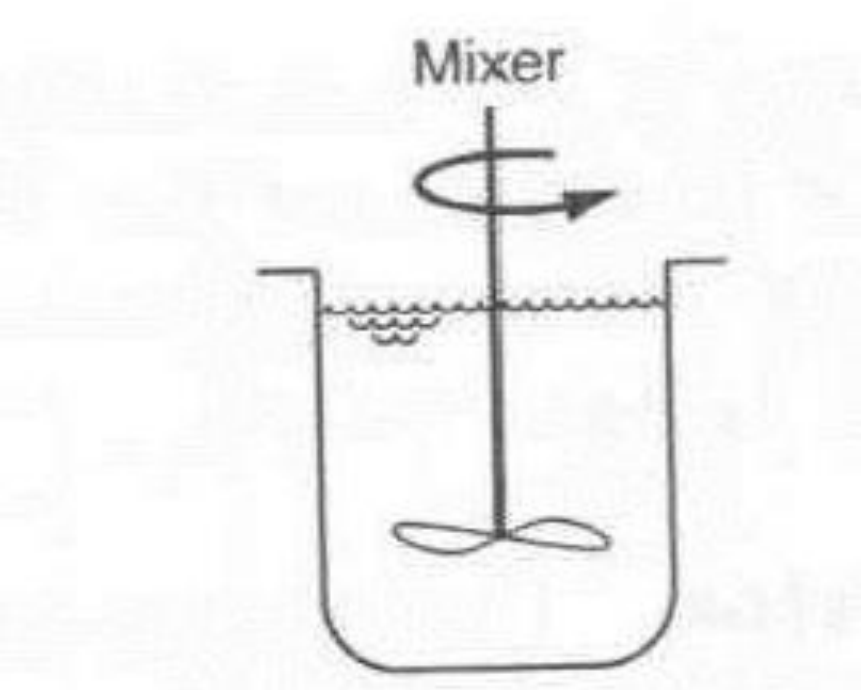
- **The need to be more efficient with the use of resources and dispersal of anthropogenic constituents into the environment (such as carbon dioxide emission).**
- **The need to avoid discharge of nutrients (that promote aquatic growth) and trace constituents.**
- **Avoiding excessive head loss and pumping as a result of poor hydraulic design.**
- **Inefficient aeration system design.**
- **Lack of consideration for the importance of primary treatment systems and anaerobic processes for BOD removal and energy recovery.**
- **Limitation is sludge reuse and ultimate disposal option.**

CLASSIFICATION OF WASTEWATER TREATMENT METHODS

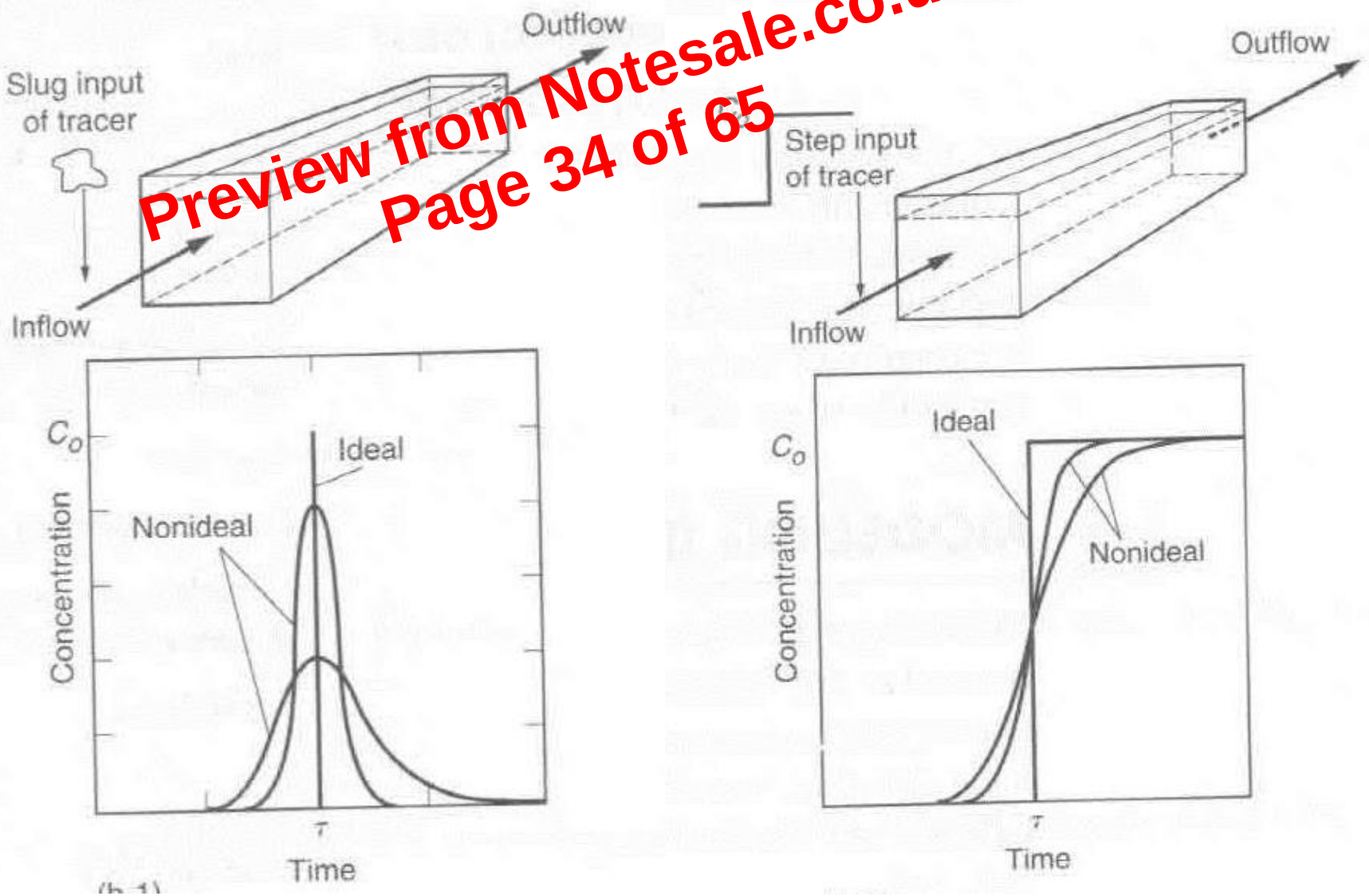
- **Constituents found in wastewater are removed by physical, chemical and biological means.**
- **The individual methods are classified as physical, chemical and biological unit processes.**
- **Physical unit processes may involve screening, mixing, flocculation, sedimentation, flotation, filtration and adsorption.**
- **Chemical unit processes remove constituents involving chemical reactions.**
- **Chemical unit processes may include: precipitation, gas transfer, adsorption, and disinfection.**
- **Biological unit processes achieve removal of constituents by biological means. Substances are converted to gas (carbon dioxide that escapes to atmosphere) and cell tissue that can be settled out be sedimentation.**
- **Biological treatment is also used to remove nitrogen and phosphorous**

REACTORS USED IN WASTEWATER TREATMENT

- **Batch reactor: Flow enters is treated and then discharged and the cycle repeats. The liquid contents of the reactor are mixed completely. They are often used to blend chemicals or dilute concentrated chemicals.**



TRACER TEST RESPONSE OF PLUG FLOW REACTOR



CHOICE OF REACTORS FOR WASTEWATER TREATMENT

Type of reactor	Applications in wastewater treatment
Batch	Conduct of BOD test, sequencing batch reactor activated sludge biological treatment, mixing of concentrated solutions into working solutions
Complete-mix without recycle	Aerated lagoons, aerobic sludge digestion, anaerobic digestion
Complete-mix with recycle	Activated sludge biological treatment
Plug-flow	Chlorine contact basin, reaeration basin, natural treatment systems
Plug-flow with recycle	Activated sludge biological treatment, aquatic treatment systems
Complete-mix reactors in series	Lagoon treatment systems, used to simulate nonideal flow in plug flow reactors
Packed bed	Nonsubmerged and submerged trickling filter biological treatment units, depth filtration, membrane filtration, adsorption, ion exchange, air stripping, natural treatment systems
Fluidized bed	Fluidized bed reactors for aerobic and anaerobic biological treatment, upflow sludge blanket reactors, air stripping, thermal oxidation of sludge

REACTION ORDER

$$r = \pm k \qquad \text{(Zero order)}$$

$$r = \pm kC \qquad \text{(First order)}$$

$$r = \pm k(C - C_s) \qquad \text{(First order)}$$

$$r = \pm kC^2 \qquad \text{(Second order)}$$

$$r = \pm kC_A C_B \qquad \text{(Second order)}$$

$$r = \pm \frac{kC}{K + C} \qquad \text{(Saturation or mixed order)}$$

$$r = \pm \frac{kC}{(1 + r_t t)^n} \qquad \text{(First order retarded)}$$

HETEROGENEOUS REACTIONS

- **Occur between one or more constituents that can be identified with specific sites such as ion exchange resins.**
- **Reactions that require the presence of solid phase catalyst are also classed as heterogeneous.**
- **Heterogeneous reactions are usually carried out in packed and fluidized bed reactors.**
- **Heterogeneous reaction involves sequence of steps for the reactions to occur**
- **Different reactions occur on different phases thus contributing to heterogeneity.**
- **Some reactions are the slowest and hence determine the overall rate of reaction.**

Flocculation	Flocculation is the term used to describe the aggregation of smaller particles into larger particles that can be removed by sedimentation and filtration. Flocculation is brought about by Brownian motion, differential velocity gradients and differential settling in which large particles overtake smaller particles and form larger particles.	Colloidal and small particles
Gas absorption/ desorption	The process whereby a gas is taken up by a liquid is known as absorption. For example, when the dissolved oxygen concentration in a body of water with a free surface is below the saturation concentration in the water, a net transfer of oxygen occurs from the atmosphere to the water. The rate of transfer (mass per unit time per unit surface area) is proportional to the amount by which the dissolved oxygen is below saturation. The addition of oxygen to water is also known as reaeration. Desorption occurs when the concentration of the gas in the liquid exceeds the saturation value, and there is a transfer from the liquid to the atmosphere.	O_2, CO_2, CH_4, NH_3, H_2S

GRAPHICAL SOLUTION OF THE WEHNER-WILHELM EQUATION