

INTELLIGENT TREND ANALYSIS IN INDUSTRIAL WASTEWATER TREATMENT

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Generalised norms

$$\| \tau M_j^p \|_p = (\tau M_j^p)^{1/p} = \left[\frac{1}{N} \sum_{i=1}^N (x_j)_i^p \right]^{1/p}$$

$$\| K_s \tau M_j^p \|_p = \left\{ \frac{1}{K_s} \sum_{i=1}^{K_s} [(\tau M_j^p)_i^{1/p}]^p \right\}^{1/p} = \left[\frac{1}{K_s} \sum_{i=1}^{K_s} [(\tau M_j^p)_i] \right]^{1/p}$$

Skewness

$$\gamma_k^p = \frac{1}{N \sigma_j^k} \sum_{i=1}^N [(x_j)_i - \| \tau M_j^p \|_p]^k \quad \gamma_3^p = 0$$

Monotonously increasing scaling functions

$$f_j^-(X_j) = a_j^- X_j^2 + b_j^- X_j + c_j, \quad X_j \in [-2, 0)$$

$$f_j^+(X_j) = a_j^+ X_j^2 + b_j^+ X_j + c_j, \quad X_j \in [0, 2]$$

$$\alpha_j^- = \frac{(c_l)_j - \min(x_j)}{c_j - (c_l)_j}, \quad \alpha_j^+ = \frac{\max(x_j) - (c_h)_j}{(c_h)_j - c_j}$$

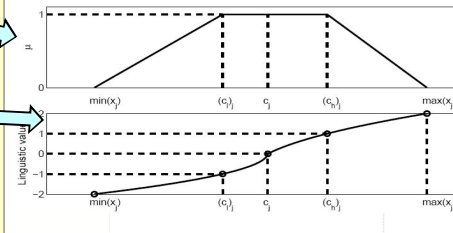
$$a_j^- = \frac{1}{2} (1 - \alpha_j^-) \Delta c_j^-, \quad a_j^+ = \frac{1}{2} (\alpha_j^+ - 1) \Delta c_j^+$$

$$b_j^- = \frac{1}{2} (3 - \alpha_j^-) \Delta c_j^-, \quad b_j^+ = \frac{1}{2} (3 - \alpha_j^+) \Delta c_j^+$$

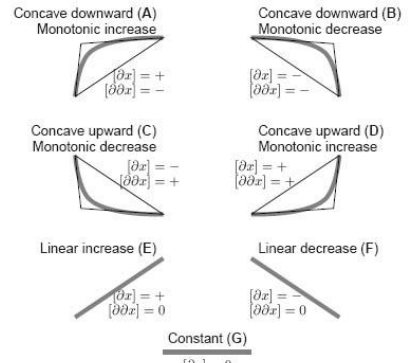
Data analysis



Nonlinear scaling $\rightarrow [-2, +2]$



Trend analysis



Intelligent trend analysis

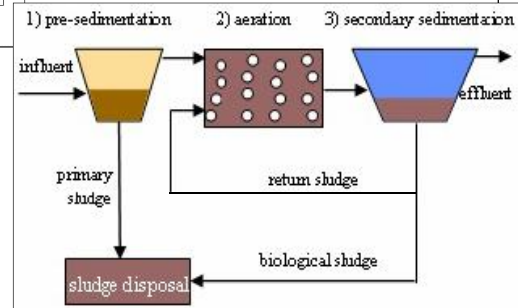
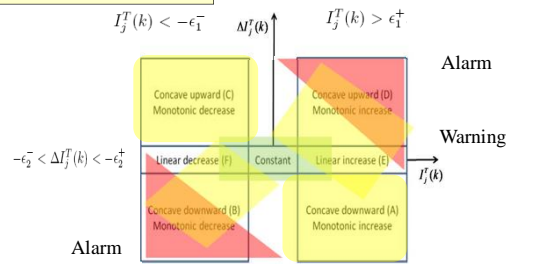
Trend index

$$I_j^T(k) = \frac{1}{n_s + 1} \sum_{i=k-n_s}^k X_j(k) - \frac{1}{n_L + 1} \sum_{i=k-n_L}^k X_j(k)$$

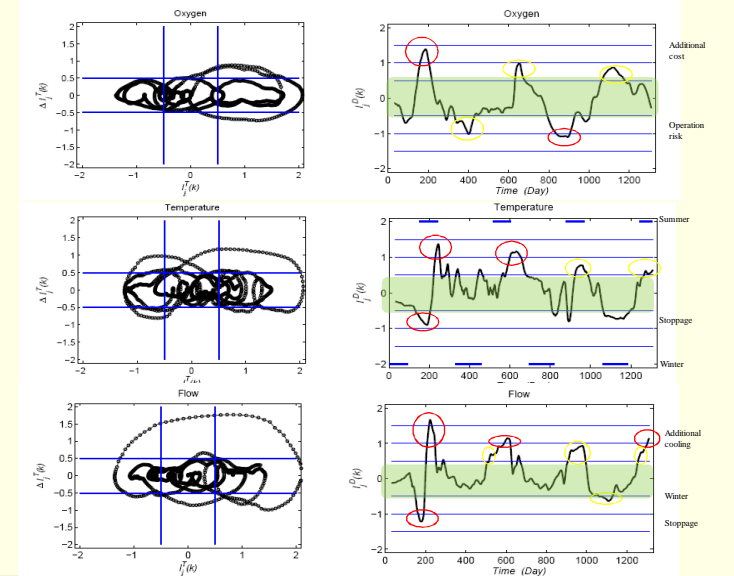
Change $\Delta I_j^T(k)$

Deviation index

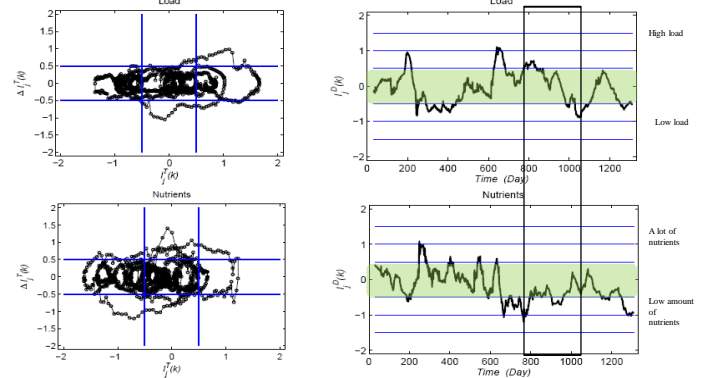
$$I_j^D(k) = \frac{1}{3} (X_j(k) + I_j^T(k) + \Delta I_j^T(k))$$



Operating conditions

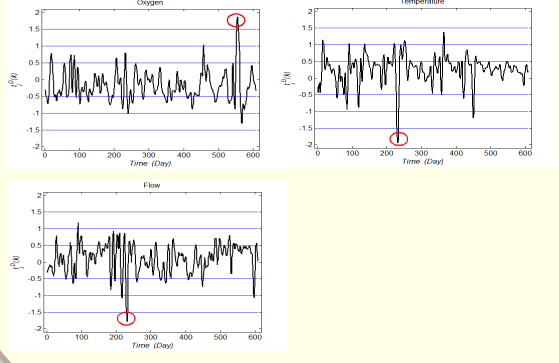


Balance = Load - Nutrients

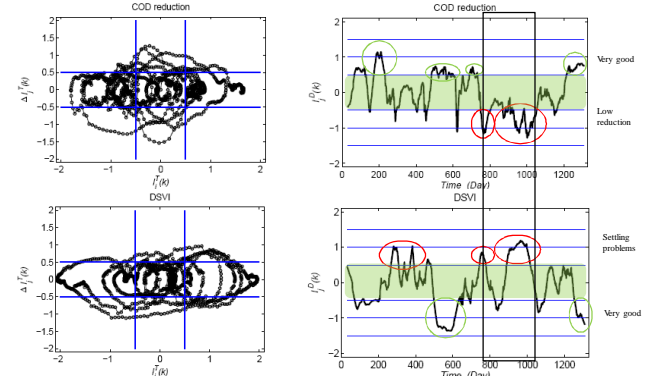
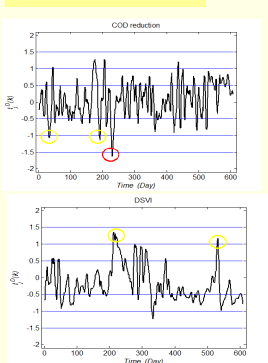


Treatment results

Operating conditions



Treatment results



Juuso, E. K. (2011), 'Intelligent Trend Indices in Detecting Changes of Operating Conditions', Proceedings of UKSim 13th International Conference on Modelling and Simulation - UKSim 2011, Cambridge, UK, 30 March - 1 April 2011, pp. 162-167. ISBN 978-0-7695-4376-5. <http://ieeexplore.ieee.org/>

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