Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 3, Issue, 9, pp. 747 - 752, September, 2012

International Journal of Recent Scientific Research

RESEARCH ARTICLE

STUDY OF STEEL RE-ROLLING MILL FOR MITIGATION MEASURES WITH SPECIAL REFERENCE TO WATER RECYCLING

*Nafees, M., [1]Zahid, Z and [2]Naz, R

*[2]Department of Environmental Sciences, University of Peshawar,Khyber Pakhtunkhwa Province, Pakistan -25120
[1]Department of Environmental Sciences, Allama Iqbal Open University, G-8 Islamabad 44000, Pakista

ARTICLE INFO

Article History:

Received 10th August, 2012
Received in revised form 20th August, 2012
Accepted 29th August, 2012
Published online 12th September, 2012

Key words:

Disinfection, $KMnO_4$, Coliform Bacteria, Threshold odor Number (TON), Water Recycling, EIA, National Environmental Quality Standards (NEQS)

ABSTRACT

Steel Re-Rolling Mill (SRM) is a simple industry consists of heating and re-rolling of billet. A heating kiln is used for the maintenance of specific temperature (1000 to 1200 ^oC) to mould billets/ingots into various desired shapes. After getting the desired shape, heavy amount of water ranging from 32 to 39 m^3 per day is used for cooling. This water is discarded on daily basis or after few weeks time. This huge amount of water creates pressure on ground water resources as well as contributing to pollution load. These aspects of steel re-rolling mill are not clearly defined in the Pakistan Environmental Impact Assessment/ Initial Environmental Examination (EIA/IEE) rules and regulations, 2000. To study the possibility of water re-cycling as mitigation measure in steel re-rolling mill was analyzed for one year. It was found that wastewater of re-rolling mill, used for cooling purpose, can be recycled after minor treatment. By the frequent re-use of the same water the possibility of biological contamination may occur. The water can be used for longer period of time after proper disinfection. To confirm its usage/re-use Potassium permanganate KMnO4 was used as disinfectant. KMnO4 treatment was given to the wastewater samples collected from storage tank with concentration of 3 mg/L, 5 mg/L and 10 mg/L. It was found that combination of 3-5 mg/L was more effective to keep the water odorless and free from coliform bacteria. After repeated use, it was suggested to discard/discharged wastewater of steel re-rolling mill only once in a year during high flow season (July-August). In this way the wastewater will be diluted to the extent that it may have no/or minimum negative impacts on the receiving the water body as well as saving the ground water resources. It is therefore, suggested required to start work on individual industry and develop specific EIA and monitoring guidelines.

INTRODUCTION

Industrial pollution is a worldwide problem. On the one hand it pollutes ecosystem, on the other side ground water is used for industrial purposes and created pressure on ground water resources as observed in Pakistan (Falkenmark, 1990). At present the water table depth is about 45 meter and a regular decrease has been noticed due to which there is decrease in tube-wells at house hold level. Heavy industrial use may also affects domestic water supply in the long run (Pak-EPA, 2004). Besides, when industrial effluents join irrigated water, it can damage crops also (Iqbal, *et al.*, 2010). Therefore, it is important to take initiatives for recycling and re-use of water along with water saving.

Like other developing countries, in Pakistan industrial development was quite slow during early fifties. Khyber Pakhtunkhwa had a small industrial basis consisted of 11 industrial units only. During late seventies and early eighties new industries have been established with a very slow rate. In 1996 there were 1848 Industrial units (Government of Pakistan, 1996 and The Daily Nation, 2003).

* Corresponding author: 0092+345-9117897
E-mail address: nafees36@yahoo.com

Nowadays the province has nearly 1151 industrial units. Out of total only 431 (37.47%) are operational (Sarhad Development Authority, 2006). In the beginning these units were haphazardly distributed, situated in and around the major cities and towns. In the first (1955-1960) and the second five years plan (1960 to 1965) establishment of separate industrial estates were approved. Later on, in the third five year plan (1965-1970) formal procedure was adopted for its proper implementation (Khan, 1976). Out of fourteen (14) industrial estates, 3 are large and eleven are small in magnitude (Government of Khyber Pakhtunkhwa, 2007). Hayatabad Peshawar, Hattar and Gadoon Amazai (Swabi) are large industrial estates, while small industrial estates include Peshawar Phase-II, Kohat Road Peshawar, Mardan Phase-I, Mardan Phase-II, Kalabat-Haripure, Abbottabad, Charsadda, Mansehra, Nowshera, Bannu, and DI Khan.

Rapid Industrialization, on one side has got positive impacts in terms of goods, services and job opportunities, but on the other side it has posed negative impacts on environment in terms of use of resources and increase in pollution. To look after environmental aspects, Environmental Impact Assessment (EIA) and Initial Environmental Examination (IEE) procedures have been adopted worldwide since 1970 (Paula, 2011). Pakistan had legislative coverage in the form of Environmental Protection Act, 1997 and IEE/EIA rules and regulation 2000. At present these rules regulations are in its initial stage of implementation, although with the approval of Environmental Protection Act 1997 EIA has been mandatory since 1997 (Government of Pakistan, 2000). Steel mill is in Schedule II for which full EIA study is required. It is a general practice that the impacts are evaluated by comparing it with Pakistan National Environmental Quality Standards (Pak-NEQS). If the resulted waste water or air emission comply the Pak-NEQS, the industry is considered as environment friendly and NOC has been granted.

Environmental Protection Agency has offered the provision for self monitoring under "Self monitoring and Reporting Rules 2001. According to this, an industry is required to submit monitoring report periodically. Two categories have been defined, placed under schedule I and II respectively. Schedule-I is for industrial effluent and schedule II is for gaseous emission. Schedule-I is further classified in to A, B, C and Special industries. Industries listed under A, B and C have to submit their monitoring report monthly, quarterly and bi-annually respectively. Industries not mentioned in any of the above categories are termed as special industries. The case is decided by EPA after proper evaluation. Steel re-rolling mill is not mentioned under any category. Although "Steel Mill" is mentioned under category a serial No. 9, but it is interpreted as large scale steel mill. Logically steel re-rolling may be placed under "special Industries" need special and modified rules. But Steel Re-Rolling mill is interpreted as exempted from reporting its effluent periodically (Government of Khyber Pakhtunkhwa, 2001).

Schedule-II, which is for gaseous emission, is classified into three categories, A, B and C. Again, steel re-rolling mill is not mentioned but at serial No. 10 "coal and oil fired Boiler, oven, furnaces and Kiln" are mentioned. Therefore, steel re-rolling can be placed here and have to submit its gaseous emission monitoring report monthly. Gas fired boiler, oven, furnace and kiln are placed under category "B" and have to submit its gaseous emission report quarterly.

For this parameters to be analyzed are mentioned under schedule-III, where water related parameters are given for "Steel Mill" include, Effluents flow, Temperature, pH, Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD5), oil and grease, phenolioc compound. For all these parameters an upper limit has been defined in Pak-National Environmental Quality Standards (Pak NEQS) except effluent flow. As mentioned earlier, steel re-rolling mill is not coming under this category "steel Mill" directly and is interpreted as exempted from reporting its industrial effluent monitoring. Besides, coliform bacteria, Threshold Odor Number (TON) are not mentioned ((Government of Khyber Pakhtunkhwa, 2001).

Studies conducted during 2007-08 revealed that EIA process was quite weak (Nadeem and Hameed, 2008). In 2011 it was pointed out that public participation was considered as major contributor in its effectiveness and was suggested to make EIA effective public participation is none of the solutions (Nadeem and Fischer, 2011). EIA is considered as systematic study to identify impacts and mitigation measure by selecting suitable measures. Use of applied science is important for identification of suitable mitigation measure. This (Cashmore, 2004). Up till now untreated wastes are discharged and dumped in and around the ground and water bodies are degrading the aquatic and terrestrial ecosystems of the province (Nafees, 2004 and Zahidullah, 2009). Besides, Hayatabad Industrial estate using ground water and continuous dependency may lead to water shortage in the vicinity as well as contribute to pollution load (Sarwar, 2011). Present studies revealed that water table in Peshawar Valley are toward decline (Pak-EPA, 2004). There are various mitigation measures, like re-use, recycling, end-of-pipe treatment, cleaner production etc (Gehin, *et al.,* 2008). But no such studied conducted on in Pakistan to evaluate a Steel Re-Rolling Mill for any of the mentioned options.

Pakistan is facing water scarcity and need to save this important resource (Steenbergen, and Oliemans, 1997). Industrial activities used huge amount of groundwater and it causes water scarcity on the one hand and cause surface water pollution on the other hand (Hussain, *et al.,* 1992). Major rivers of Pakistan in general and of Khyber Pakhtunkhwa in particular are contaminated and not safe for drinking (Nafees, 2004).

Water recycling is a technical and most complicated method (Jeffrey, *et al.,* 1999). Before devising a recycling method a pre assessment in terms of quantity and quality is essential. In which waste water quality is of prime importance (Ahmad, and Dessouky, 2008). As waste water is stored in storage tank, therefore, various hurdles can appear in the form of bad smell, color and turbidity. This forced the industrialist to use fresh water (Liu, 2010).To cope with such situation, usually disinfections are used. The common disinfections used for raw water treatment includes Chlorination, and UV-treatment. But these are expensive and are justifiable for potable water only. Other popular disinfectants include the use of potassium per maganate ($KMnO_4$) and lime. These can be used in isolation or in combination, depending on water quality. $KMnO_4$ is a colored compound and may be required in excess with a long retention time (Magalhaes and Neves, 2003). A suitable range for raw-water treatment is 5-10 mg/L (Richardson *et a.l,* 1995). Besides, in high concentration it is toxic. Therefore, a low dose of 10 or less is preferred (USEPA, 1999 and Nwadiaro, et.al, 2010).To increase its effectiveness other compounds are added as supplement for enhancement. These include Cu, Ag and lime. But there is always a trade off in terms of retention time and cost (Gerba, *et al.,* 1989).

Steel mill is a common industry in Khyber Pakhtunkhwa. It is a simple industry, consists of two major steps i.e. heating and re-rolling where water is used for cooling. In total there are 103 steel related industrial units out of which 52 units are situated in Peshawar. Out of 52 units, 42 are accommodated in Hayatabad Industrial Estate. The average production of a steel re-rolling mill is 0.5 million tons/year (Government of Khyber Pakhtunkhwa, 2007). On the average 5% of the raw material is wasted during production and is re-cycled inside the plant. On the average a SRM consume 38 – 40 M^3 water, which is used for cooling. In theory this water will be reused as it will remain in circulation and develop foul smell and color. Due to presence of odor the water is considered as source of skin and other diseases and is usually discarded as waste water.

In this study an attempt has been made to overcome on the problems of odor and coliform bacteria and make this used water recyclable for a longer period of time with the idea to reduce pressure on ground water resources and avoid/ reduce surface water pollution.

METHODOLOGY

To assess water quality for recycling three composite samples were collected per month in a calendar year. Each composite sample consisted of four grab samples collected with one hour interval. Samples was analyzed for Temperature, Odor, pH, E.C, TSS, TDS, Turbidity, BOD, COD, Iron, Cupper and coliform bacteria by following standard method. These parameters, except odor are mentioned in Pak-NEQS and the list was used for comparison.

The same samples were subjected KMnO4 treatment for identification of proper dose. Various doses of 3mg/L, 5mg/L, 10mg/L and 15mg/L were applied and were monitored for coliform and Threshold Odor Number (TON). For coliform bacteria (cfu/100 ml) a simple filtration and incubation method was used (Romprea, *et. al.*, 2002).

RESULTS AND DISCUSSION

Water use

The daily water usage ranged from 31.94 M^3 to 44.39 M^3 (31940L to 44390L) per day in different seasons of the year with the annual average of 13489.18 M^3 (Table 1). A fraction ranged form 0.5 to 1.0% consumed per day in the form of evaporation. This amount of water (0.5 to 1.0%) equivalent to 200 to 400 L will have to be added daily to the storage tank. Underground water is the major source in Hayatabad Industrial Estate. At present there are three steel re-rolling mills in Hayatabad industrial estate and consume 110.8575 M^3 (36.9525 * 3 M^3) water per day. The wastewater consisting of iron-scale will mainly be treated in settling tanks through the process of sedimentation. The scale will settle in sedimentation tanks that will be cleaned out and sold to the contractor. If a Steel Re-rolling mill is based on freshwater with no storage and recycling facilities, will consume 13489.18 M^3annually.

Table 1 Detail of Average Daily Water Used in Steel Re-Rolling Mill during 12 Hours Shift

Period	Total Records	Min (M^3/s)	Max (M^3/s)	Average (M^3/s)	Estimated Annual use (M^3/s)
Jan-March	9	28.22	34.25	31.94	11658.1
April- Jun	9	37.23	48.34	43.39	15838.57
Jul – Sept	9	32.78	42.89	36.86	13456.33
Oct-Dec	9	31.56	39.82	35.62	13003.73
Average Annual	36	32.4475	41.325	36.9525	13489.18

Continuous extraction of water can lead to ground water resource degradation and need to be reduced at the source. It is, therefore, desired to circulate the cooling again and again and avoid ground water depletion. By repeated circulation for cooling, with the passage of time water gets contaminated with dirt and also produces bad smell and the water is released as waste water after a few weeks.

Characteristics of used /wastewater

The average values of different parameters (Table 2), based on six month record shows that majority of parameters were within the permissible limits when compared with Pakistan National Environmental Quality Standards (Pak-NEQS). Besides, it is also not part of the routine monitoring program mentioned in the EIA/IEE regulation 2000. In this way it is not obligatory on the industry to arrange treatment for this type of wastewater. The direct discharge may have no negative impact on the receiving the water body (Kabul River) but its recycling can decrease pressure on ground water resources on one hand and can decrease pollution load of the receiving water body on the other hand along with saving electricity.

Temperature ranges from 35 to 43 ^oC with the average of 39.43 ^oC. This range is not a problem in winter but can encourage the bacterial growth in the storage tank. In summer the atmospheric temperature remains above 40 ^oC (Government of Khyber Pakhtunkhwa, 2011). Therefore, the cooling capacity of the stored water will be minimum and extra-cooling system may be required. Which is usually achieved by i) mixing fresh water, ii) increase the capacity of storage tank by increasing the surface area instead of increasing the depth or iii) pass water from cascade and tray tower (Manan, 2004). The direct release may have no impact on the aquatic life as the receiving water body (Kabul River) is at a distance of more than 25 Km. Therefore, cannot increase surface temperature of Kabul Rive to such an extent that may have negative impacts.

The high temperature can affect the availability of dissolved oxygen of the used/wastewater. In the presence of 15-20 mg/L BOD and 45-95 mg/L COD, along with temperature of 42-48 ^oC will encourage bacteriological activity in the form of decomposition. Due to lake of oxygen anaerobic conditions will prevail to produce bad smell which is a big hurdle in re-cycling.

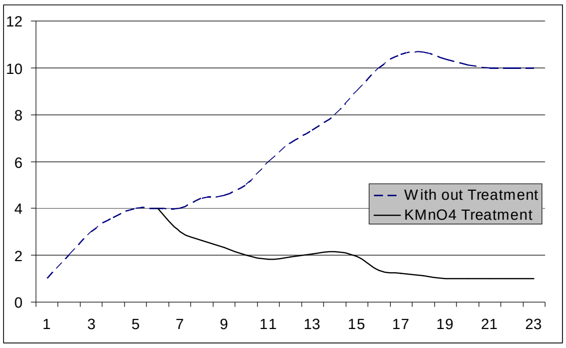

Fig. 1 Graph showing trend in Threshold Odor Number (TON) with and without KMnO4 Treatment (5mg/l)

From re-cycling point of view, two parameters, which is not mentioned in the list of Pak-NEQS were objectionable i.e. odor and turbidity. US-EPA had set a limit of of 3 Threshold Odor Number (TON) for drinking water (Peavy, et al., 1985, Lin, et. al., 2002). Threshold Odor Number (TON) of steel mill was ranged from 7 to 13 with an average of 9.57 (Table 2). This has got physiological impression and on the basis of bad-smell the water is considered as polluted (Lin, et. al., 2002). Although, a slight treatment in the form of disinfection can remove bad smell and the water can be made recyclable (Paris, and Schlapp, 2010). As some water (0.5 to 1.0%) daily consumed during cooling system and fresh water is added daily. Dilution is one possible solution to remove odor but for removal of odor with 9.5 TON (Table 2) need 297.5 M^3 fresh water. Therefore, the daily addition of 0.5 to 1.0% water equivalent to 0.175 M^3 to 0.35 M^3 cannot solve the odor problem.

as in TON. As $KMnO_4$ is toxic in greater quantity therefore, a minimum dose is always recommended (Reynolds, 1989). With the help of 3 mg/L a decreasing trend was observed up to 10 days. 5mg/L completely destroy all sort of pathogen after 3 hours retention time while 2 mg/L shows its effect in 5 hours. As $KMnO_4$ remained dissolved for weeks and months, therefore, a minimum does (2-5 mg/L) is preferred to make wastewater safe and odor free. The required amount of $KMnO_4$ comes out as 175 gram/35 m^3 @ rate of 5 mg/L. $KMnO_4$ worked as strong biocide in acidic media (low pH) and worked as oxidizing agent at pH above 7. During repeated recycling the pH remain at higher sides, which decrease its effectiveness toward coliform bacteria. In this way bacteria are killed by oxidizing effect of KMnO4. Therefore, a dose of 5 mg/L was identified as suitable. In this concentration the odor remains below 2 TON (Fig-1). By analyzing table 5 the killing effect is slow which is due to incomplete mixing. Contents were within the permissible limits and may have no effect on environment. Odor, Turbidity and coliform bacteria are parameters that are not mentioned in EIA rules regulation 2000 and making the steel re-rolling water objectionable and

Table 2 Analytical Results of Waste Water

S.NO	Parameter	Units	Results			NEQS	Standard Method used
			Min	Max	Average		
1.	T (C^0)	C^0	35.00	48.00	39.43	40	Thermometer
2.	Odor	TON	7.00	13.00	9.57	N-D	Quantitative
3.	pH	--	7.59	8.01	7.79	6-10	Digital PH-meter
4.	E.C	µs/cm	805	912	861.86	N-D	Conductivity meter
5.	TSS	mg/l	75	95	84.57	150	Gravimetric
6.	TDS	mg/l	1333	1824	1722.14	3500	Gravimetric
7.	Turbidity	NTU	25	55	36.43	N-D	Instrumentation
8.	BOD5	mg/l	15.00	20.00	17.57	1.72	5 days incubation.
9	COD	Mg/l	45	95	76.25	150	Reflux Method
10	Iron	mg/l	2.54	3.87	3.28	8.00	AAS
11	Cupper	mg/l	0.22	1.25	0.49	1.00	AAS

Turbidity is the second parameter which determines whether the water is polluted or not which is, caused by suspended and colloidal material. It is not necessary that turbid water is dangerous (Pavanelli1, and Bigi, 2005).Therefore, a slight treatment in the form of sedimentation and coagulation can solve the problem. As observed in re-rolling mill, the storage used water get an overnight retention time, which is enough time to allow the suspended load settled and make the water less objectionable.

Table 3 Growth of Coli-form Bacteria with out any Treatment

Day	Fresh Water			Waste Water			Blank (De-ionized Distilled Water)		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Before Incubation	4	8	4.8	400	870	664.3	0	2	0.8
After 48 hours Incubation	10	20	14.4	1100	4500	3214.3	1	4	2.1
Increase	8	12	10	700	3600	2550.1	1	2	1.3

Table 4 Response of Coli-form Bacteria toward Different Doses of $KMnO_4$

Conc	3 mg/l			5mg/l			10 mg/l			15 mg/l		
Duration	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1^{st} day	30	90	60	20	50	38.6	10	40	28.6	5	20	14.3
After five days	10	20	13.6	6	16	10	2	6	3.7	1	3	1.9
After 10 days	4	10	6.7	1	6	3.1	0	2	1.1	0	1	0.6

The third important parameter is coliform bacteria. It is a general perception and is also observed that the stagnant water is considered as source of pathogens and un-safe (Richardson, 1995). It was found that waste water has got 400 to 900 cfu/100 ml coliform bacteria. After 48 hours incubation at 25°C a bulk increase of 2-5 times was recorded. The minimum increase of 1100 (almost double) to 4500 (about 5 times) was recorded (Table 3). This high increasing trend not only contributing to the odor but also is a potential source of disease.

To remove the hazard of biological contamination and odor, different doses of $KMnO_4$ were applied (Table 4). With the increasing dose there was decrease in coliform bacteria as well

CONCLUSION

According to the present rules regulation, industries are placed under main sectors of different nature in terms of environmental impacts. Parameters like pH; TDS, Iron and Cu appeared as hurdle in its re-cycling. It can create water scarcity in Peshawar. It is therefore, recommended to create separate guideline for each industry by including status of water use in

EIA as well as in routine monitoring program. The overall discussions show that the used/wastewater of steel re-rolling is recyclable. For coliform bacteria and odor Problems KMnO4 treatment is suggested. $KMnO_4$ may be added at once in the concentration of 5mg/L or on daily basis in small doses of 1-2 mg/L. The best option is to start with 3 mg/L and after monitoring $KMnO_4$ level at regular interval to add further $KMnO_4$. To increase the effectiveness of $KMnO_4$ a uniform mixing is therefore, one of suggestion. For uniform mixing the water storage must have two separate chambers. The first chamber will serve as mixing and sedimentation tank and will be cleaned periodically while the second Chamber store water for re-cycling.

References

Ahmad, J., and Dessouky, H. E. L. 2008. Design of a modified low cost treatment system for the recycling and reuse of laundry waste water. Resources, Conservation and Recycling 52(7):973–978.

Cashmore, M. 2004. The role of science in environmental impact assessment: process and procedure versus purpose in the development of theory, Environmental Impact Assessment Review 24 (2004) 403–426

Falkenmark, M. 1990. Global Water Issues Confronting Humanity. Journal of Peace Research, 27(2):177-190.

Gehin,A., Zwolinski, P. Brissaud, D. 2008. A tool to implement sustainable end-of-life strategies in the product development phase. Journal of Cleaner Production, 16(5):566-576.

Gerba, C.P., Kutz, S.M., Landeen, L.K. and Yahya, M.T. 1989. Swimming Pool Disinfection, An Evaluation of the Efficacy of Copper: Silver Ions. Journal of Environmental Health, 51(5):282-285.

Government of Khyber Pakhtunkhwa. 2007. Directory of Industrial Establishments, 2007. Industries, commerce, Labor, Mineral Development, Technical Education Department, Government of Khyber Pakhtunkhwa. 18-25

Government of Khyber Pakhtunkhwa (GOKP). 2001. National Environmental Quality Standards (Self-Monitoring and Reporting by Industry) Rule, 2001.web page: http://www.environment.gov.pk/NEQS/selfmon_ru01.pdf. p: 4-5

Government of Pakistan. 2000. Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations, 2000. 1-18.

Government of Khyber Pakhtunkhwa. 2011. Climate: Southern Khyber Pakhtunkhwa. Official web page of Khyber Pakhtunkhwa province, Directorate of Information Technology, Government of Khyber Pakhtunkhwa web page:http://www.khyberpakhtunkhwa.gov.pk/aboutus/Climate.php.

Government of Pakistan. 1996. Bureau of statistics, ‘‘NWFP development statistics 1995 and 1996”. Planning,

Environment and Development Department (NWFP), Peshawar.Hussain, A. and Ali, A.A. 1992. Environmental Problem in Pakistan; their origins and Development and the Threats that they pose to Sustainable Development. Environment and Urbanization, 4(1):8-21.

Iqbal, Z., Qureshi, T.M., Akhtar, M. and Akhtar, J. 2010. Evaluation of industrial effluents for reclaiming salt-affected soil and achieving economic crop productivity. Soil & Environ. 29(1): 87 - 90,

Jeffrey P., Seaton, R., Parsons, S., Stephenson, T., and Jefferson, B. 1999. Exploring water recycling options for urban environments: a multi-criteria modeling approach. Urban Water, 1(3):187-200.

Khan, J (1976) ‘‘Development of Industrial Estate in Peshawar” Institute of development studies, agriculture university Peshawar NWFP Pakistan.

Lin, T.F., Wong, J.Y. and Kao, H. P. 2002. Correlation of musty odor and 2-MIB in two drinking water treatment plants in South Taiwan. The Science of The Total Environment, 289(1-3):225-235

Liu, S., Butler, D., Memonb, F.A., Makropoulos, C., Avery, L.M. and Jefferson, B. 2010. Impacts of residence time during storage on potential of water saving for grey water recycling system. Water research, 44(1):267–277

Magalhaes F. and Neves, M. 2003. Cleaning and Disinfection of Water Supply Systems. Electron. J. Environ. Agric. Food Chem, 2(2):267-273.

Manan, A.A., Tan, Y.L. and Foo, D .C. Y. 2004. Targeting the minimum water flow rate using water cascade analysis technique, 50 (12):3169–3183.

Nadeem, O. and Fischer, T.B. 2011. An evaluation framework for effective public participation in EIA in Pakistan. Environmental Impact Assessment Review 31 (1): 36–47.

Nadeem,O and Hameed, R. 2008. Evaluation of environmental impact assessment system in Pakistan Environmental Impact Assessment Review 28 (8) 562–571.

Nafees M. 2004. Environmental of Study of Kabul River and its Tributaries in Khyber Pakhtunkhwa, Pakistan. M.Phil Thesis, Department or Environmental Sciences, University of Peshawar, 102-110.

Nwadiaro, P.O. and Ejimadu, L.C. 2010. Evaluation of Acute Effects of Potassium Permanganate on The Nile Tilapia Orechromis niloticus. Nigerian Annals of Natural Science, 10(1):1–8

Pak-EPA/OECC. 2004. Urban Environmental Problems in Pakistan: A Case Study for Urban Environment in Hayatabad, Report Published by Pakistan Environmental Protection Agency (EPA), Islamabad and Overseas Environmental Cooperation Center (OECC), Japan, pp-47-48.

Paris, S., Schlapp, C. 2010. Greywater recycling in Vietnam - Application of the HUBER MBR process. Desalination, 250 (3):1027–1030.

Pavanelli1, D. and Bigi, A. 2005. Indirect Methods to Estimate Suspended Sediment Concentration: Reliability and Relationship of Turbidity and Settleable Solids. Biosystems Engineering, 90(1):75-83

Peavy, H.A., Row, D. R.. and Tchobanoglous, G. 1985. Environmental Engineering. Mc-Graw Hill Book Company, New-York, p-136-137.

Paula J. P. 2011. Exploring climate change criteria for strategic environmental assessments, Progress in Planning, 75(3):109-154

Richardson T., Duranceau, J. S., Laliberte, D. and Dehler, G. R. 1995. Full-Scale Implementation of a Carbonic Acid Aeration System for Hydrogen Sulfide Removal. Florida Water Resource Journal, 23-30.

Romprea, A., Servais, P., Baudarta, J., de-Roubinc, M. and Laurenta, P. 2002. Detection and enumeration of coliform in drinking water: current methods and emerging approaches,Journal of Microbiological Methods, 49(1):31-54

Reynolds, G., Mekras, C., Perry, R. and Graham, N. 1989. Alternative disinfectant chemicals for trihalomethane control: a review. Environmental Technology Letters, 10: 591–595.

Sarhad Development Authority (SDA) 2006. Investment Policies and Opportunities in Khyber Pakhtunkhwa, Pakistan, Investment Facilitation Centre, Government of Khyber Pakhtunkhwa, p-10

Sarwar, A. Q.2011.Water Management in the Indus Basin in Pakistan: Challenges and Opportunities. Mountain Research and Development 31(3):252-260.

Steenbergen, F.V., and Oliemans, W., 1997, Groundwater resource management in Pakistan, en Schrevel, A. (ed.), IRLI workshop: Groundwater Management: sharing responsibility for an open access resource, Proceedings of the Wageningen Water Workshop 1997: The Netherlands, ILRI, pp: 93–110.

The Daily Nation, News Paper. 2003. Ecno-List, Directory of Industrial Establishment in NWFP" Islamabad, March 6.

USEPA. 1999. Guidance Manual for Alternative Disinfectants and Oxidants. United State Environmental Protection Agency, 5.1 - 5.15.

Zahidullah. 2009. Study of Physicochemical and Treatment facilities for Industrial Waste Water of Hayatabad Industrial, Estate Peshawar, Pakistan" PhD thesis, department of environmental sciences, university of Peshawar, 55-75

****