Green Power Technology to Clean the Hussain Sagar Lake and Support its Neighborhood Energy Utility.

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Wastewater treatment plants are an important component of urban cities and with exponential industrial and population growth, the volume of materials these plants have to accommodate is growing by several orders of magnitude. This consumes large amount of fossil fuels based power. Escalation in fossil fuel cost is a deterrent to many wastewater treatment plants. Heat pump and heat exchanger technology that is commonly adopted in geothermal industry can be integrated with wastewater treatment plants thus implementing clean development mechanism (CDM) in several urban cities

Introduction

There is a growing concern world over on the global climate change due to carbon dioxide emission from fossil fuel based thermal power plants. The carbon dioxide concentration in the atmosphere prior to industrial revolution was less than about 350 ppm while in the last decade the concentration shot beyond 450 ppm (IPCC, 2007). For example, the estimated carbon dioxide emission level in India in 2004 was 399 ppm while it is projected to cross 600 ppm by the year 2012 due to high industrial and population growth (Chandrasekharam et al., 2006; Chandrasekharam and Varun Chandrasekhar, 2007). This projected increase in carbon dioxide emission is due to the country's ambitious programme to increase the current power generation capacity of 123,668 MWe to 215,000 MWe by 2012. This amounts to burning additional 263 million tones of coal and releasing 870 million tones of carbon dioxide. With the implementation of Kyoto Protocol, India has to reduce emission by 5 %. This amounts to large reduction in power production from fossil fuel based thermal power plants. This 5 % of emission reduction can be achieved, like other countries, by adapting source mix for power generation with out compromising country's GDP growth. Heat pumps and heat exchangers play a greater role in maintaining GDP growth as well as mitigating carbon dioxide emission. This method has been deployed successfully in several countries in supplementing power from a source other than fossil fuels thereby reducing dependence on conventional sources. Heat pumps and heat exchangers can support power utilities by heating or cooling the buildings, supply hot water and provide electric power. Thus this system offsets the use of fossil fuels without curtailing the electricity needs, thus providing solution to mitigate carbon dioxide emission. This clean development mechanism (CDM) is in practice world over and is saving electricity cost and providing clean environment. Heat pump and heat exchanger technology can be utilized in wastewater treatment plants. The added advantage is that such a system not only provides clean water but also provided electric power, supplies hot water and heats and cools the space. Thus wastewater treatment plants can be made as stand-alone systems providing additional benefits to the local communities.

Heat exchangers and heat pumps

Heat exchangers are devices that can efficiently transfer heat from one fluid to another. These are extensively used in geothermal industry for generating electric power through binary cycle technology from geothermal fluids and also to heat or cool building using ground heat. Figure 1 shows the basic concept of electric power generated in a geothermal power plant.

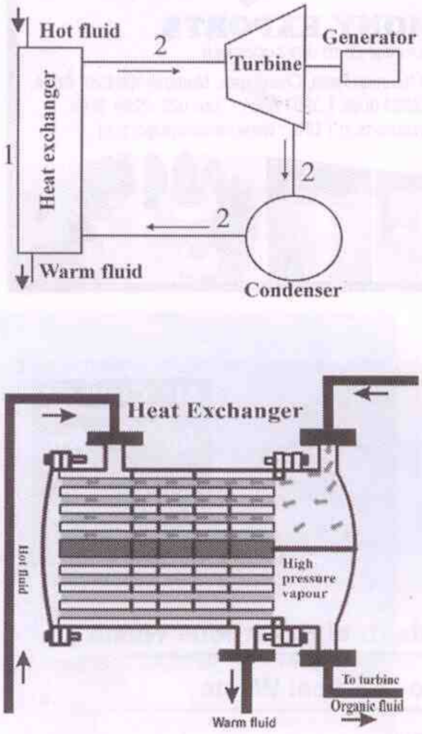

Figure 1. a). Schematic diagram of a geothermal power plant. 1 indicates circulation path of the hot fluid and 2 indicate circulation path of the secondary fluid. b) A typical heat exchanger.

The heat exchanger consists of a series of "U" tubes (Fig. 1b) through which hot fluid circulates. A secondary fluid with low boiling point is made to circulate outside the U tubes. The secondary fluid picks up heat from the hot fluids and evaporates and passes through the turbine. This high pressure vaporized secondary fluid rotates the turbine thus generating electric power. The vapour is then condensed and allowed to flow back into the heat exchanger. The warm fluid that is ejected from the heat exchanger can be utilized further for space heating/ cooling purpose using a heat pump.

Heat pumps are extensively used for space heating and cooling purposes by capturing ground heat (Rybach, 2001). A heat pump does the function of a refrigerator. It moves heat energy from one entity to another entity. In heating applications, heat is removed from the ambient air, water, or ground and delivered to a room. Thus in winters, the rooms can be kept warm. The same pump work in a reverse way, by removing the heat from a room and sink it to the ground. Thus the rooms are kept cool. Heat exchangers in conjunction with the heat pumps are extensively used for heating and cooling homes, district heating etc. in Europe and other western countries (Rybach, 2001). It is apparent from the above that with the help of a heat exchanger and a heat pump, heat from any source can be utilized for various purposes. This technology is very useful in various industries and is being effectively used by several countries as detailed in the subsequent paragraphs. If the source temperature is high, then the heat exchanger can help in generating electric power as well as supporting space heating and cooling systems. This system can be well implemented in wastewater treatment plants. Such systems will not only clean the water but also generate power to support the water treatment plant and

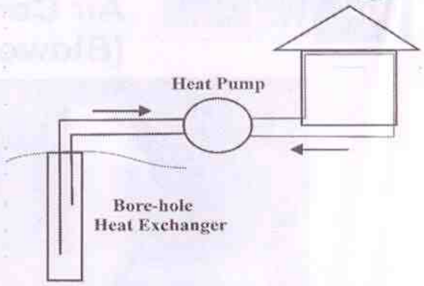

Figure 2. Schematic diagram showing the configuration of heat exchanger and heat pump in heating and cooling application. The heat pump uses the heat extracted by the heat exchanger and heats the home in winter and in a reverse process, the home is cooled during summer. The function of the heat pump is similar to a air-conditioner (modified after Sanner, 2001).

Combined heat and power in astewater treatement

Wastewater treatment plants receive wastewater both from industrial and domestic sources. A generalized flow diagram of a wastewater treatment plant is shown in figure 3.

The raw industrial and domestic wastewater contains a mixture of several organic and inorganic compounds that need to be removed before the water can be reused for purposes other than drinking. The wastewater undergoes a series of biological, chemical and

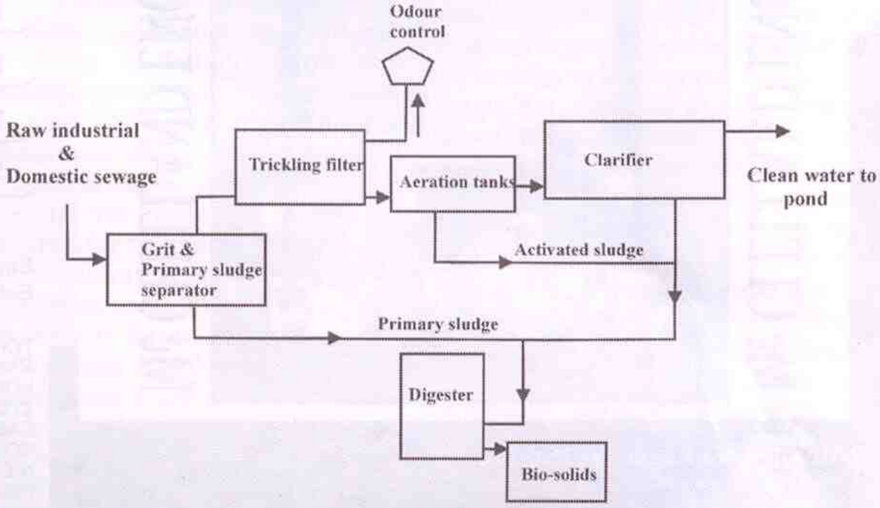

Figure 3. Generalized flow chart of a wastewater treatment plant (modified, W P C F, 1975).

physical processes before it becomes clean. Thus during the primary treatment, grit and sludge is separated from the wastewater. In the secondary treatment, aeration and BOD removal takes place followed by the nutrients removal and denitrification and phosphorous removal. During all these stages, sludge is separated and removed to separate tanks (Fig. 3) for further processing. Disposal of sludge is a complex and expensive process in wastewater treatment. Complete disintegration of the sludge is necessary to dispose the sludge in an environmentally acceptable fashion. Temperature plays an important role in sludge digestion and disposal. The operating temperature for mesophilic and thermophilic sludge digesters are in the range of 38 to 60^{o}C. Highest temperature of the order of 100 to 700^{o} C is required for drying and incarnation of the sludge (WPCF, 1975 water pollution control federation) . The remaining solids after this process are environmentally friendly solids that can be disposed easily. To obtain this temperature, the water treatment plant has to depend on thermal power. Here heat exchangers and heat pumps can play a major role. The heat exchanger and heat pump technology can be integrated with the sludge disposal system thereby generating electric power (see fig. 1) to run the entire wastewater treatment plant, supply hot water to the water treatment plant and provide cooling and heating facility to the plant supporting structure. Depending on the volume of the sludge generated, electric power, hot water and space cooling and heating facility can be extended to the surrounding public and private buildings. Further, the methane generated from anaerobic digester can also supplement the energy needs of the water treatment plant.

Heat pump used in Beijing 2008 Olympic village

A huge heat pump system has been used in Beijing 2008 Olympic village. The heat source is regeneration water from the Qing River Wastewater Treatment Plant (WWTP). Earlier, the Qing River WWTP discharges its regeneration water into Qing River. The regeneration water has a constant temperature of 12-20^{o}C in winters and 20-30^{o}C in summers. Considering the flow rate of 400,000 m3/d, this regeneration water contains large heat resource. This resource has been used for district heating and cooling in Beijing 2008 Olympic Village. There are 410,500 m^{2} of building area (except underground space) in the Olympic Village. The total demand of energy load is 28.2 MW cooling load for summers and 20.9 heating load for winters. The regeneration water is discharged into Qing River after extracting heat using clean water circulating through heat exchangers. The clean water from heat exchangers is circulated through a series of heat pump system to generate heat for winter heating and to absorb heat for summer cooling of the Olympic village. A schematic diagram of such system is shown in Figure 4. Thus the indoor temperature of the entire village is conditioned at 18-22^{o}C while the out door air temperature is at 31^{o}C.

This project has substituted fossil fuel and reduced CO2 emission and created substantial economic, environmental and social benefits.

Albert Lea Wastewater treatment facility, Minnesota, USA.

This wastewater treatment plant generate 120 KW of power using combined Heat and Power technology (CHP). The hot digester gases are captured and the heat is recovered using heat exchangers and heat pumps and converted to electric power with the help of micro-turbines. According to a report published by the Minnesota Department of Commerce in 2005, the advantage of CHP systems over conventional systems is that CHP is able to save 25% of energy (about US$ 40,000/yr) and project cost is about US$ 250,000 with a payback period of 4 years (www.CHPCenterMW.org).

Essex Junction wastewater treatment plant, Vermont.

Methane generated from anaerobic digester in a wastewater treatment plant is used to generate 60 KW of electric power. This system works with 80 % efficiency with annual savings of 36%. The annual energy saving due to the implementation of CHP is about 412,000 kWh /yr. The total cost of the project is US$ 30,300 with a pay-back period of 7 years. After the installation, this facility prevented 272,400 kg emission of carbon dioxide. This power plant besides supplying power to the wastewater treatment plant, supported its neighborhood utilities by supplying hot water, power as well providing cooling and heating facility to the buildings (www.northeastchp.org).

Sustainable development of The Hussain Sagar Lake:

Hussain Sagar Lake is situated in the middle of urban Hyderabad city in

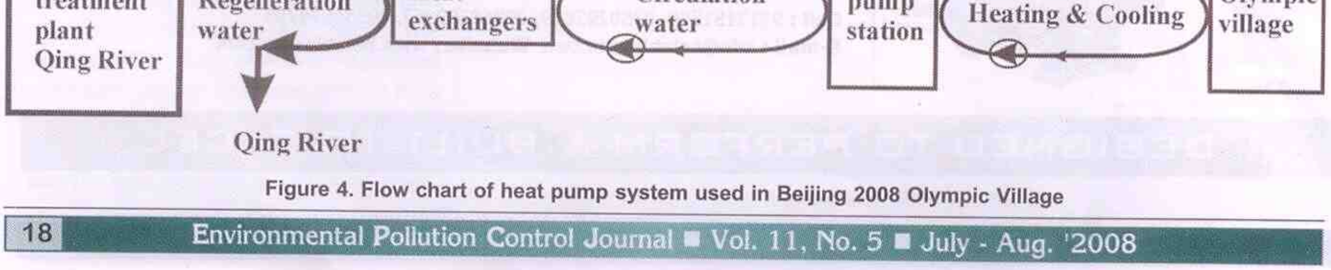

Figure 4. Flow chart of heat pump system used in Beijing 2008 Olympic Village

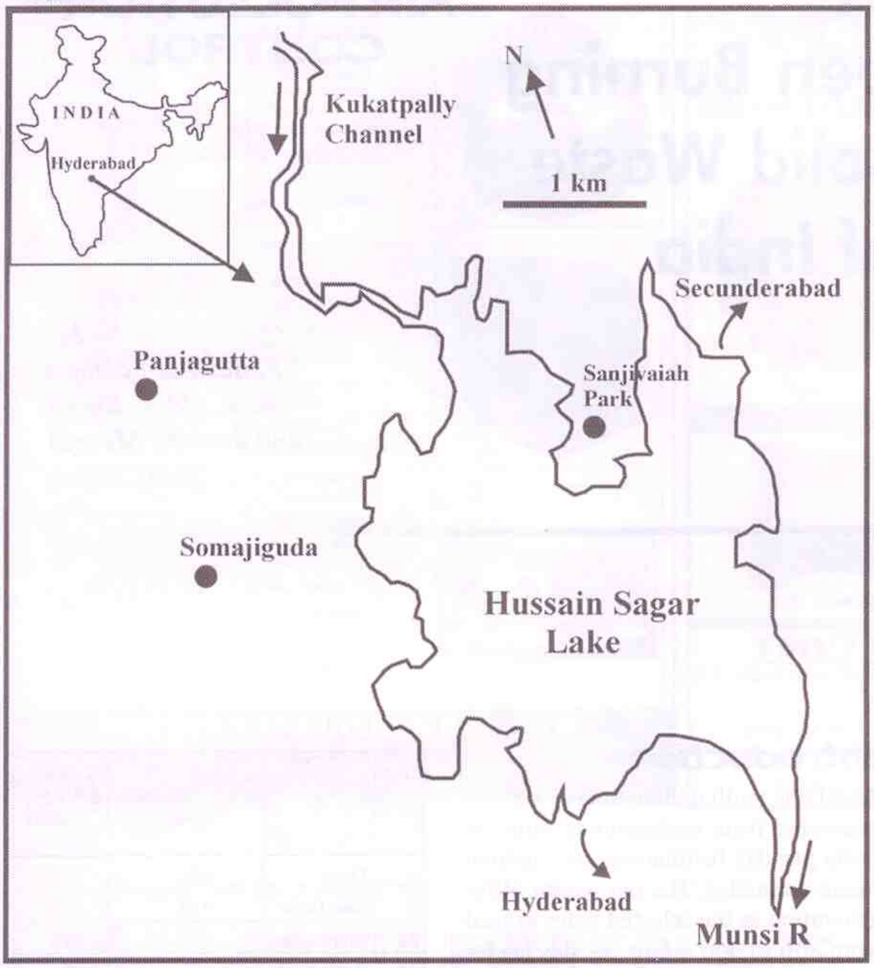

Figure 5. Hussain Sagar Lake in Hyderabad, India

Andhra Pradesh. This lake is created due to a bund constructed across the Musi river (Fig. 5). Due to rapid urbanization of the city, population and industrial growth made this lake a dumping ground for domestic and industrial waste. The lake receives 18,650 m3/d of domestic sewage and 9,540 m3/d of industrial effluent. Unless an integrated plan is formulated to treat the sewage and use the byproducts to the benefit of the lake system, it is difficult to sustain the development of the lake eco-system.

Like any other mega cities of the world, generation of domestic sewage and industrial effluents is a part of the growing city system. Solution is available, likes those discussed above, to keep the lake ecosystem clean and continue the growth of the industrial and urban development around the lake. The lake has to receive large input of water to maintain its health and support the surrounding natural habitat. This is possible if the inflow of domestic and industrial effluents are used to co-generate electric power and supply treated water into the lake. A combined wastewater treatment plant and power generation system can be deployed near Kukatpalli lake intake point so that the lake continue to receive treated water with low nutrient content and at the same time the sludge generated can be disposed after co generating electric power using micro turbines. The electric power thus generated from the wastewater treatment plant can be supplied to the plant to sustain its life and also to the neighborhood establishments around the lake. Besides electric power, facilities to cool and heat the buildings can be installed in all the public and private utilities surrounding the lake. Thus the public utilities surrounding the lake can utilize green energy from the wastewater treatment plant and reduce carbon dioxide emission thereby earning additional revenue through carbon credits.

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