Research Paper

Volume : 3 | Issue : 6 | June 2014 • ISSN No 2277 - 8179

# Dairy Farm Waste Management; An Approach For River Water Restoration, Environment Improvement and Waste to Energy Generation, in Delhi, India

Environment

**KEYWORDS :** Dairy Waste Management; Waste to energy generation; River water restoration; GHG Emissions; Solid Waste Management.

| | |
|---|---|
| *** Dilip K. Sharma** | College of Environmental Science and Engineering, UNEP-Tongji Institute of Environment for Sustainable Development, Tongji University, Shanghai,P.R.China. *Corresponding Author |
| **Uma Bhargav** | School of Resources and Environmental Science, East China Normal University, Shanghai, P.R.China |
| *** Fengting Li** | College of Environmental Science and Engineering, UNEP-Tongji Institute of Environment for Sustainable Development, 1239, Siping Road, Tongji University, Shanghai 200092, China *Corresponding Author |

## ABSTRACT

*During a study to abate the environmental pollution load and improve the water quality of the river Yamuna in Delhi, India, a major component 'Dairy Farm Waste' had been recognized as one of the prominent source of wastewater pollution and solid waste discharge. Cattle excreta was discharged and dumped from authorized dairy farms and has emerged to be one of the major non- point source of water pollution and point source for land pollution in Delhi. The estimated biogas emission from dairy farm waste was 42222 m3/day (approx.), leading to hazardous environmental impacts. According to the current findings, electricity generation of 3.7 MW (approx.) can be achieved by utilizing the available technical cattle excreta, which have 32034 m3 (approx.) of biogas generation potential per day. The study represents policy implications and other major findings/ data obtained by commencing survey, laboratory analysis, and site observations during planning of Dairy Farm Waste Management.*

## 1. Introduction:

The key objective of the study was to access the findings of environmental pollution load, green house gas emissions and methodology adopted for the improvement of water quality of river Yamuna by abating non point sources of water pollution.

Yamuna is a prominent water resource in India. It is 1370 Km long river, along downstream it stretches only 22 Km in Delhi, whereas suffers 70% of pollution load there. To control the Yamuna river pollution in Delhi, during Yamuna Action Phase-I (YAP-I) various components had been identified [Sharma D. & Kansal A, 2011]. Among them, for Yamuna eco system conservation a framework of combined strategy for biogas generation and resource conservation was laid out by separately targeting the dairy farms in Delhi. Dairy farms were termed for clusters of dairy units run by private owners for dairy farming on a land allotted on lease by Municipal cooperation of Delhi at urban outskirts, to promote milk production in Delhi.

In Yamuna Action Plan-II (YAP-II) an initiative to develop comprehensive Master Plan for non- sewerage component Dairy Farm Waste Management (DFWM), a detailed feasibility study for setting up sustainable facility for handling cattle dung waste/ liquid waste, area development and enhancing the downstream water quality for implementation of pilot project was taken[Sharma D. & Kansal A, 2011].

India is the highest milk producing country in the world, having its annual milk production of 112.5 million tons in 2010 [Annual report MoA, GoI, 2010-11], but the milk productivity per capita is very low. The rapid changes in demand for dairying as profession, in Delhi, India had exerted unprecedented pressure on the resources and environment. The demand for more milk production was largely met by increased number of animals rather than lesser number of efficient milk producing animals. The cumulative effect of higher demand for milk, increased animal population, availability of limited space and higher cost of distribution had rapidly changed the economic scenario for livestock rising in Delhi, India. Milk productivity in conjunction with processing generated waste in the form of solids, liquids and gases. These wastes were dumped on surrounding land, mostly flushed with water and finally discharged into the river, leads to environmental pollution, methane and other GHG emission, and causing environmental hazards.

In order to develop a framework of combined strategy for Yamuna river water quality improvement, it was realized that primarily the discharge of waste from dairies into urban water bodies need to be resolved. Hence Dairy Farm Waste Management (DFWM) Plan was formulated, to identity options for cattle waste management (from dairies) such as biogas generation to energy production, composting, vermin culture, other alternatives for storage of animal waste, included prevention of wastage of ground water and electricity by minimizing flushing activity.

This study represents the major findings and summarized data obtained by commencing survey, group discussions, laboratory analysis, and site observations during Stage-1 of Master planning of the Dairy Farm Waste Management (DFWM).

## 2. Methodology:

### 2.1 Site analysis and survey

2.2 A questionnaire had been developed and survey was conducted at 10 authorized dairy farm sites practicing dairy business in Delhi. On the basis of primarily survey done, the authorized dairy farms had been located in 5 Municipal Zones of Delhi, shown in Table.1. Shahadra south Zone contain Gazipur and Gharoli Dairy Farms, Civil Line Zone demarcated Bhalswa and Jharoda Dairy Farms, Shahbad Daulatpur Dairy Farm comes in Rohini Zone, Central Zone covers Masoodpur and Madanpur Khadar Dairy Farms and Nazafgarh Zone included, Goela, Nangli & Kakrola Dairy Farms shown in Fig.1. These dairy farms approximately cover an area of 1615830 $m^2$ calculated by GIS mapping on the basis of land use map, detailed in Table.1.


**Fig.1. Location map of the Authorized Dairy Farms in Delhi, India (Not to scale)**

**2.3 Estimation of Quantity of Dung Generation:**
The quantity of dung generation from the dairy clusters was of utmost importance to quantify the biogas emissions, to assess its capacity for biogas production and to select suitable and economically viable technology to utilize this waste. Following methodology to quantify dung generation was applied.

All the animals were categorized into three categories, first category includes animals in good health having body weight of 500-600 kg, given better feed. According to Crampton et al., 65% of the dry matter feed can be digested and adsorbed by these animals and 35% of dry matter remains undigested excreted in the form of dung. Whereas animals with average body weight of 400-500kg and average health can digest 45-50% of the dry matter feed, on contrary only 35-40% of the dry matter can be digested by animals having low body weight ≤400kg & with poor health. As dung contains 80-85% moisture approximately, the total dung generation can be quantified on wet basis [Crampton E.W. & Harrio L.E., 1969]. So during the survey the count of animal with good, average and poor health and the feed given was considered important aspect in questionnaire developed.

**2.4 Estimation of Biogas Generation**
As reported 1 Kg animal dung yields approximately an average of 37 liters biogas at a temperature of 20-30ºC with a retention period of 30-60 days. Accordingly, the total biogas potential was calculated [Christopher Hansen, 2007][K.L. Chadda & M.S. Swami Nathan, 2006].

**2.5 Characterization of Waste**
Chemical analysis of animal waste was conducted at National Dairy Research Institute (NDRI), India laboratories. The samples of dung from different breeds of adult cattle, categorized as domestic buffalo, domestic cow, hybrid buffalo, hybrid cow and their calves were collected. 5 samples for each category were collected. They appeared to be fibrous, semi-solid, and brownish in color with temp. 37-39°C. The average values of aggregated results for chemical characterization were observed.

**2.6 Waste to Energy Generation**
Dairy farms waste had proven noticeable local and global environmental impacts, but if this waste had been managed properly and by technological intervention, potential for renewable energy production can be generated. Hence for feasibility of concept, a study for the biogas potential from waste and electricity generation capacity from biogas was conducted. The technical dung was estimated by considering 20% loss during collection process and biogas potential of this waste was calculated. Finally the power plant capacity for waste to electricity generation for each dairy farm was calculated, considering 8.5 $m^3$ of biogas can generate 1KW of electricity [Patankar M. Pat-

Volume : 3 | Issue : 6 | June 2014 • ISSN No 2277 - 8179

wardhan A, and Verbong G, 2010].

### 3. Results

Findings from surveyed data and field analysis were compiled for estimation of waste generation, GHG emissions and biogas potential of waste for energy generation are represented in Table 2 and 3. The chemical characteristics of animal waste generated from dairies are represented in Table 4. Looking into the gravity of the problem and its environmental consequences, implementation of Dairy Farm Waste Management Plan was strongly recommended.

**Table.1. Distribution and location of authorized dairy farms in Delhi, India.**

| No. | Name of Zone | Name of Dairy Farm | Latitude & Longitude | Elevation | Total Area ( In m2) |
|---|---|---|---|---|---|
| 1 | Shahadra South Zone | Gazipur | N 28037'467" E 77019'344" | 202 | 290660 |
| | | Gharoli | N 28036'888" E 77019'901" | 209 | 403470 |
| 2 | Central Zone | Madanpur Khadar | N 28031'788" E 77017'650" | 312 | 58970 |
| | | Masoodpur | N 28031'717" E 77009'034" | 275 | 70100 |
| 3 | Nazafgarh Zone | Goela | N 28034'726" E 77001'756" | 227 | 222250 |
| | | Nangli | N 28037'261" E 77000'812" | 203 | 184100 |
| | | Kakrola | N 28036'956" E 77001'489" | 211 | 72450 |
| 4 | Civil Line Zone | Jharoda | N 28044'093" E 77011'933" | 198 | 81570 |
| | | Bhalswa | N 28044'469" E 77009'960" | 195 | 146250 |
| 5 | Rohini Zone | Shahbad Daulatpur | N 28044'666" E 77005'834" | 207 | 86010 |

**Table.2. Functional dairy units in each dairy farm, dung generation and biogas emissions**

| No. | Municipal Zone | Authorized Dairy Farm (Dairy clusters) | Dairy unit Surveyed | | | Total No. of Cattle | Dung Generation Ton/ Day | Estimated Biogas Emissions $m^3$/day |
|---|---|---|---|---|---|---|---|---|
| | | | Functional | Abandon | Total | | | |
| 1 | Shahdara South Zone | Gazipur | 799 | 165 | 964 | 15411 | 292.73 | 10099.18 |
| | | Gharoli | 392 | 2280 | 2672 | 3328 | 69.88 | 2410.86 |
| 2 | Civil Line Zone | Bhalswa | 553 | 743 | 1296 | 3419 | 60.50 | 1385.50 |
| | | Jharoda | 374 | 92 | 466 | 2655 | 57.41 | 2223.40 |
| 3 | Rohini Zone | Shahbad Daulatpur | 63 | 580 | 649 | 501 | 10.92 | 434.40 |
| 4 | Central Zone | Madanpur | 180 | 26 | 206 | 4781 | 105.57 | 4251.40 |
| 5 | Nazafgarh Zone | Masoodpur | 195 | 33 | 228 | 4025 | 86.80 | 3580.80 |
| | | Goela | 1410 | 462 | 1872 | 8201 | 186.16 | 7209.30 |
| | | Nangli | 1264 | 108 | 1372 | 10939 | 247.22 | 8309.90 |
| | | Kakrola | 548 | 430 | 118 | 2595 | 60.46 | 2316.90 |
| | | Total | 10273 | 5660 | 4607 | 55855 | 1177.65 | 42221.64 |

**Table.3. Estimated technical dung generation, biogas and electricity generation potential in each dairy farm.**

| S. No. | Municipal Zone | Name of the Authorised Dairy | Total Dung Generation/ Day (in tones) | Technical Dung/ Day | Biogas Potential ($m^3$/ day) | Power generation potential (KW) | Remarks; Installation of Power Plant |
|---|---|---|---|---|---|---|---|
| 1 | Shahdara South Zone | Gazipur | 293 | 234 | 7962 | 937 | 1000 KW |
| | | Gharoli | 70 | 56 | 1901 | 224 | 250 KW |
| 2 | Civil Line Zone | Bhalswa | 61 | 48 | 1646 | 194 | 250 KW |
| | | Jharoda | 57 | 46 | 1562 | 184 | 200 KW |
| 3 | Central Zone | Madanpur | 106 | 84 | 2872 | 338 | 350 KW |
| 4 | Nazafgarh Zone | Masoodpur | 87 | 69 | 2361 | 278 | 250 KW |
| | | Goela | 186 | 149 | 5064 | 596 | 600 KW |
| | | Nangli | 247 | 198 | 6724 | 791 | 800 KW |
| | | Kakrola | 60 | 48 | 1645 | 193 | 200 KW |
| 5 | Rohini Zone | Shahbad Daulatpur | 11 | 9 | 297 | 35 | Not suggested, can be used for vermin-composting |
| | | Total | 1178 | 941 | 32034 | 3770 | |

**Table 4. Chemical characteristics for different categories of cattle waste**

| Parameter (in %) | Domestic Buffalo | Hybrid Buffalo | Domestic Cow | Hybrid Cow | Buffalo Calf |
|---|---|---|---|---|---|
| Dry Matter (DM) | 15.41 | 13.83 | 15.46 | 13.85 | 15.12 |
| Moisture | 84.58 | 86.17 | 84.53 | 86.15 | 84.88 |
| Crude Protein (DM basis) | 13.54 | 15.54 | 10.35 | 7.12 | 11.95 |
| Crude Fat | 1.56 | 1.96 | 1.90 | 1.95 | 2.24 |
| Crude Fiber | 34.72 | 33.69 | 28.27 | 30.31 | 28.83 |
| Total Ash | 12.51 | 12.14 | 17.15 | 16.77 | 10.90 |
| Acid in Soluble Ash (DM basis) | 8.41 | 7.06 | 13.61 | 12.65 | 8.01 |
| Nitrogen Free Extractives (NFE) | 37.65 | 36.66 | 43.66 | 43.99 | 46.07 |
| Nitrogen | 0.30 | 0.32 | 0.18 | 0.12 | 0.32 |
| Nitrogen (DM basis) | 2.47 | 2.09 | 1.12 | 1.04 | 2.18 |

### 4. Discussion

Survey statistics, laboratory analysis and findings drawn indicates that almost 45% of dairy units in authorized dairy farms were misused or abandoned and non-functional, also most of them had been converted to illegal residential units The overcrowding of animals for large profit intentions was leading 2- 5 times higher density than its carrying capacity in most dairy units. The operating conditions of the dairies were unhealthy and unhygienic. It was observed that all around scattered dung, chocked drainage, pervasive stink, mosquito menace, unplanned haphazard settlement, broken roads, interrupted power & water supply, extremely depleted water table, and lack of basic health facilities were at stake of explosiveness of the situation.

Maximum amount of animal excreta was flushed with water resulting in huge effluent discharged to nearby drainages (Nazafgarh drain, Supplementary drain, Agra canal, Kondli drain) (Fig.1.) without any treatment, which finally open in Yamuna River. Water table was depleting continuously due to excessive

ground water consumption for flushing activities and can cause shortage of ground water in long run.

Among dairy farms human habitation was rampant. Surroundings were filthy and severe environment hazards were observed. Stakeholders raised questions on organizational deficiencies and lacking facilities also they were not aware about scientific techniques of area improvement including shelter management, quality of water, cattle dung management, cause of environment pollution and its prevention, waste water treatment technologies and landscaping of surroundings for friendly environment. It was also observed that dairy operators had low level of literacy, unawareness towards their rights and responsibilities, unawareness of running policies and programs, negative attitude for developmental activities and was lacking moral- ethical values.

In order to share the responsibilities for managing the dairy farm waste significantly and to address this in effective manner it was extremely important for both, the dairy stakeholders and the Government to have Memorandum of Understanding (MoU). Also for institutional strengthening of DFWM plan formulation of an Information Dissemination Cell (IDC) (Fig.2.) is suggested. Policies should be formulated for proper organizational management as suggested in IDC.

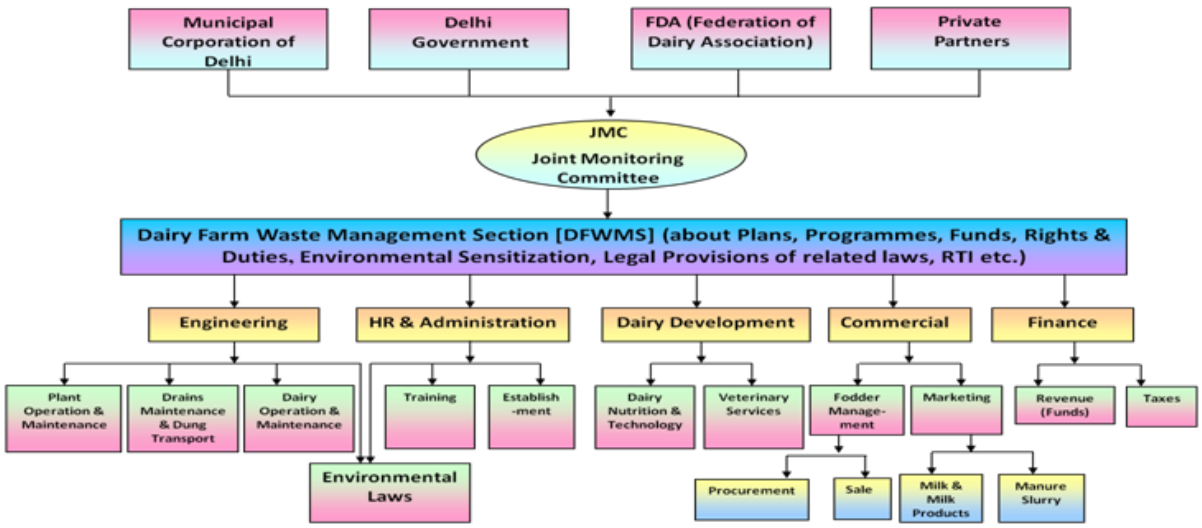


**Fig.2. Information Dissemination Cell (IDC) for Institutional Strengthening of DFWMS**

Successful models of waste treatment [Arvanitoyannis IS & Giakoundis A., 2006] and waste to energy generation [Patankar M. et al., 2010] should be followed and could be implemented. For instance, biomethanation power generation plant of appropriate capacity can be installed for cattle dung management in the dairy farms. Whereas, the dung can be used for bio-fertilizer production by developing vermin-compost units in dairy farms generating less animal excreta. Dairy farm effluent should be appropriately treated before discharged to urban water bodies. UASB technology was recommended as an economical viable technology for treatment of dairy waste water. Other models of waste water treatment [Healy MG, Rodgers M, and Mulqueen J, 2007][Karpiscak M. M., R. J. Freitas, et al., 1999] could also be followed.

Enhancement of reorientation training was of paramount importance for stakeholders to collaborate with new partners and creation of other new frameworks. Dairy stakeholders should be trained for application of scientific techniques for dairy business and improving their surroundings. It was recommended by implementing advance dairy practices the economics of dairy can be changed from high expenses to nominal expenses and high profits, this will lead to sustainability.

## 5. Conclusion:

The existing Dairy farms in Delhi have strong local and global environmental impacts of GHG emissions estimated 42222 m3/day (approx.) because environmental policy guidelines and legislation had not been followed for waste management & sustainance of such operation by stakeholders. Besides that, electricity of 3.7 MW (approx.) can be generated by utilizing the available technical cattle excreta, which have 32034 m3 (approx.) of biogas generation potential per day. Also dairying proved to be a profitable business in Delhi, which has turnover of approx. $72.4 Million and a profit of $ 0.64 Million after meeting all expenditure, interest and depreciation (ref. financial analysis during the project). Therefore, DFWM Plan was a best approach for Yamuna water pollution control, environment improvement and GHG emission control by waste to energy generation.

**Acknowledgement :** We would extend sincere thanks to Tongji University & East China Normal University (Shanghai, China), MSV International Inc. (MSV-Gurgaon, India), Municipal Cooperation of Delhi (MCD, India) & Project Management Consultants (PMC- Delhi, India) Conservation Directorate (NRCD-India) & Japan Bank of International Cooperation (JBIC-Japan).

## REFERENCE

[1] Arvanitoyannis IS, Giakoundis A, 2006. Current Strategies for Dairy Waste Management: A Review. Critical Reviews in Food Sci and Nutrition. 46(5):379-90. | [2] Annual Report 2010-2011, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, Government of India. | [3] Crampton E.W. and Harrio L.E., 1969. "Applied Animal Nutrition: the use of feed stuff in the formulation of Livestock rations". 2nd edition, W.H. Freeman and Company. pp 105-123 | [4] Christopher Hansen, 2007. "Report on the feasibility of year round Biogas Generation at the UBC Farm". pp 1-12. | [5] Healy MG, Rodgers M, Mulqueen J, 2007. Treatment of dairy wastewater using constructed wetlands and intermittent sand filters. Bioresour Technol. 98(12):2268-81. | [6] Karpiscak M. M., R. J. Freitas, et al., 1999. "Management of dairy waste in the Sonoran Desert using constructed wetland technology". Water Sci Technol. 40(3):57-65. | [7] K.L. Chadha & M.S. Swami Nathan (2006). "Environment & Agriculture" Biogas Technology. 43, pp 835-853. | [8] Patankar M, Patwardhan A, Verbong G, 2010. A promising niche: waste to energy project in the Indian dairy sector. Environ Sci Policy. 13(4):282-90. | [9] Sharma D. and Kansal A, 2011."The status and effects of Yamuna Action Plan YAP". |