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Discovering Thoughts, Inventing Future

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Contents of the Volume

i. Copyright Notice
ii. Editorial Board Members
iii. Chief Author and Dean
iv. Table of Contents
v. From the Chief Editor's Desk
vi. Research and Review Papers

1. Use of Dehydrated Peeled Fruit of *Luffa Cyllindrica* as Support Medium in Trickling Filters: Analysis of its Performance Regarding the Reduction of the Organic Content and Microbiologic Considerations. *1-13*
2. Neuro-Dynamic Optimization of Biotechnological Process. *15-19*
3. What is the Most Environmentally-Friendly Utilization of Biomasses? *21-25*
4. Relations between Anthropometric Dimensions and Overcome Resistance in Individual Motion. *27-31*
5. Predictive Values of Motor Dimensions in Motor Space. *33-40*
6. A Review of Bird Control Methods at Airports. *41-50*
7. Combined Control Scheme for Monitoring Quality Characteristics. *51-57*

vii. Auxiliary Memberships
viii. Process of Submission of Research Paper
ix. Preferred Author Guidelines
x. Index

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Use of Dehydrated Peeled Fruit of *Luffa Cyllindrica* as Support Medium in Trickling Filters: Analysis of Its Performance Regarding the Reduction of the Organic Content and Microbiologic Considerations

By Marcos R. Vianna, Gilberto C. B. De Melo & Márcio R. V. Neto
Universidade FUMEC, Brazil

Abstract- Domestic sewage treatment experiments were conducted in trickling filters in laboratory pilot plants in which the peeled dehydrated fruits of *Luffa cyllindrica* were used as a support medium for microbiological growth, in order to verify its capacity to remove organic matter, measured in terms of Biochemical Oxygen Demand ($BOD_{5,\ 20}$) and Chemical Oxygen Demand (COD). The results obtained, when compared to results from similar pilot plant using stones as supporting medium, indicated that *Luffa cyllindrica* can substitute, under specific conditions, the traditional support media. Also, although detailed microbiologic studies were not among the objectives of this study, it was observed that the biofilm found in *Luffa cyllindrica* was richer in species and in a higher evolutive stadium than the biofilm found in the stones. Further studies are recommended.

Keywords: trickling filters; microbiology of trickling filters; luffa cyllindrica; biofilms; alternative support media; wastewater treatment.

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Use of Dehydrated Peeled Fruit of *Luffa Cyllindrica* as Support Medium in Trickling Filters: Analysis of Its Performance Regarding the Reduction of the Organic Content and Microbiologic Considerations

Marcos R. Vianna[α], Gilberto C. B. De Melo[σ] & Márcio R. V. Neto[ρ]

Abstract- Domestic sewage treatment experiments were conducted in trickling filters in laboratory pilot plants in which the peeled dehydrated fruits of *Luffa cyllindrica* were used as a support medium for microbiological growth, in order to verify its capacity to remove organic matter, measured in terms of Biochemical Oxygen Demand ($BOD_{5,\ 20}$) and Chemical Oxygen Demand (COD). The results obtained, when compared to results from similar pilot plant using stones as supporting medium, indicated that *Luffa cyllindrica* can substitute, under specific conditions, the traditional support media. Also, although detailed microbiologic studies were not among the objectives of this study, it was observed that the biofilm found in *Luffa cyllindrica* was richer in species and in a higher evolutive stadium than the biofilm found in the stones. Further studies are recommended.

Keywords: trickling filters; microbiology of trickling filters; luffa cyllindrica; biofilms; alternative support media; wastewater treatment.

I. Introduction

A trickling filter, whose typical configuration is shown in figure 1, is an aerobic process for wastewater treatment that is simple to build and to operate. It is used for the treatment of domestic and industrial effluents. Its operation consists in passing the liquid effluent through a support media. A biologic film develops over the surface of the medium. The biologic activity developed on this film will be responsible for the stabilization of the organic content of the effluent. It is distributed by means of a rotative arm, over the support media. The bio film remains part of the time in contact with the effluent and part of the time exposed to the atmosphere and, in this way, to the oxygen of the air.

According to Matasci et al (1988), this treatment process was largely used in the United States, but has declined because of the increasing legal exigencies in that country regarding the organic content in the treated effluent. In Brazil as in many other developing countries, in which the lack of domestic wastewater treatment plants is still a problem, trickling filters can be an adequate solution, especially for small communities.

The degree of stabilization achieved depends on many factors, such as: volumetric and organic loading, kind of support medium, temperature, ventilation, among others, but it hardly achieves values beyond 85% in terms of $BOD_{5,20}$ removal, according to WEF & ASCE (1992). The higher the desired removal efficiency, the higher will be the necessary sophistication and complexity of the facility.

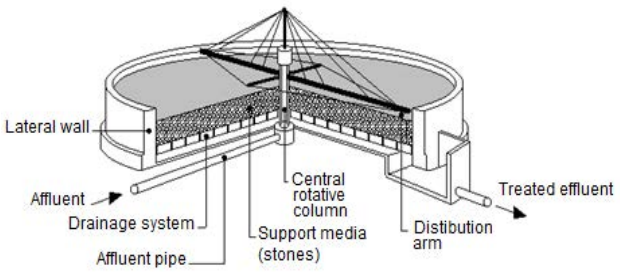


Figure 1: Typical trickling filter. Figure adapted from Jordão and Pessoa (2009).

Regaring the support medium, the greater the offered specific surface, the greater will be its efficiency. With this purpose, pieces of coking coal, which presents a porous nature, are used in some installations, as well as plastic media especially developed for this purpose.

The use of of *Luffa cyllindrica* was the poposed innovation of this study. This plant – see figure 2 – can be found all over the Brazilian territory. Its dehydrated peeled fruit is commonly used as natural sponge for bathing and cleansing, for handicraft activities, in pharmacology and in some industries. It is characterized by a very fibrous structure, which offers a great surface for biological film fixation, with very small specific gravity, and when dehydrated it degrades very slowly, because of its natural function of keeping the seeds for plant propagation. For that reason, it was

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devised that it could be used to perform this extra function as a medium in trickling filters.



(a) Plant and flower



(b) Dehydrated peeled fruit

Figure 2 : *Luffa cyllindrica* (a) plant and flower; (b) traditional dehydratedPeeled fruit, according to<http://cucurbitaceae. livejournal.com/7702.html?Thread =19222 > (accessed in 16/04/2014).

Studies concerning the use of *Luffa cyllindrica* for wastewater treatment are few, and specifically as biofilm supporting medium in trickling filters are unknown. In Brazil, Agra (2009) studied its use as substrate in continuous submerged attached growth pilot bioreactors. The results obtained showed that these reactors were efficient for carbonaceous matter stabilization and in the nitrification process. Sousa *et al*. (2008) studied its use for the immobilization of nitrifying bacteria in a laboratory-scale submerged attached growth bioreactor for polishing the effluent of an UASB reactor treating domestic wastewater. In Mexico, Ruiz-Marin *et al*. (2009) compared results obtained in semi-continuous reactors using *Luffa cyllindrica* and PVC support medium. Artificial wastewater was used in the study, and higher percent phosphorus removals were obtained in *Luffa cyllindrica* reactors. The use of the plant for the treatment of nondomestic effluents is also reported. In Brazil, Oliveira (2007) studied its use for metallic ions and dyes removal in textile industries effluents. In Algeria, Laidani *et al.* (2010) studied copper adsorption by *Luffa cyllindrica* fibers. In Nigeria, Oboh *et al.* (2011) studied the use of this material as a biosorbent for removal of divalent metals from aqueous solutions.

When considering the microbioloby of the trickling filters, the studies are insuficient. Regading to trickling filters in which *Luffa cyllindrica* is used as support medium, these studies do not exist.

Branco (1978) describes the composition of the biologically active film which covers each one of the stones in the upper layer of a trickling filter as follows, see figure 3.

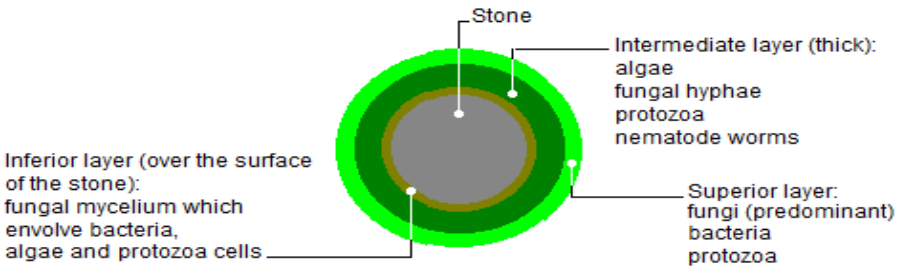


Figure 3 : Composition of the biofilm on a trickling filter support medium, as described by Branco, 1976.

- ✓ *Superior layer:* predominance of fungii; bacteria; protozoa;
- ✓ *Intermediate layer (thick):* algae, filamentous or not (only in the stones hit by sunlight); fungal hyphae; protozoa; nematode worms;
- ✓ *Inferior layer (over the surface of the stone):* fungal mycelium which envolve bactéria, algae and protozoa cells.

The main objective of this experimental work was to assess the behaviour and capability of the peeled dehydrated fruit of *Luffa cyllindrica* to act as a

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bio film support medium in trickling filters, for stabilization of the organic matter of domestic sewage. For this purpose, traditionally used parameters in the evaluation of sewage treatment were measured - Biochemical Oxygen Demand ($BOD_{5,20}$), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Settle able Solids (Set S) – in the affluent and effluent of trickling columns filled with this material, and the results were compared to others obtained from a similar trickling column filled with stones. Besides, taking into account that studies concerning the microbiology of these filters could not be found, it has tried to determine, in a preliminary and rough way, the main biologic composition of the bio films developed over the *Luffa cyllinrica* and rocks medium.

II. Experimental Work

The experimental work was conducted in a pilot scale treatment plant constructed according to the description that follows (Fig. 4). Raw sewage stream was taken from a domestic sewage sewer of the city of Belo Horizonte, and continually pumped to an inlet chamber which functioned as a grit chamber. Within this unit the effluent was also screened and, after that, homogenized in the chamber by means of a mechanical mixer.

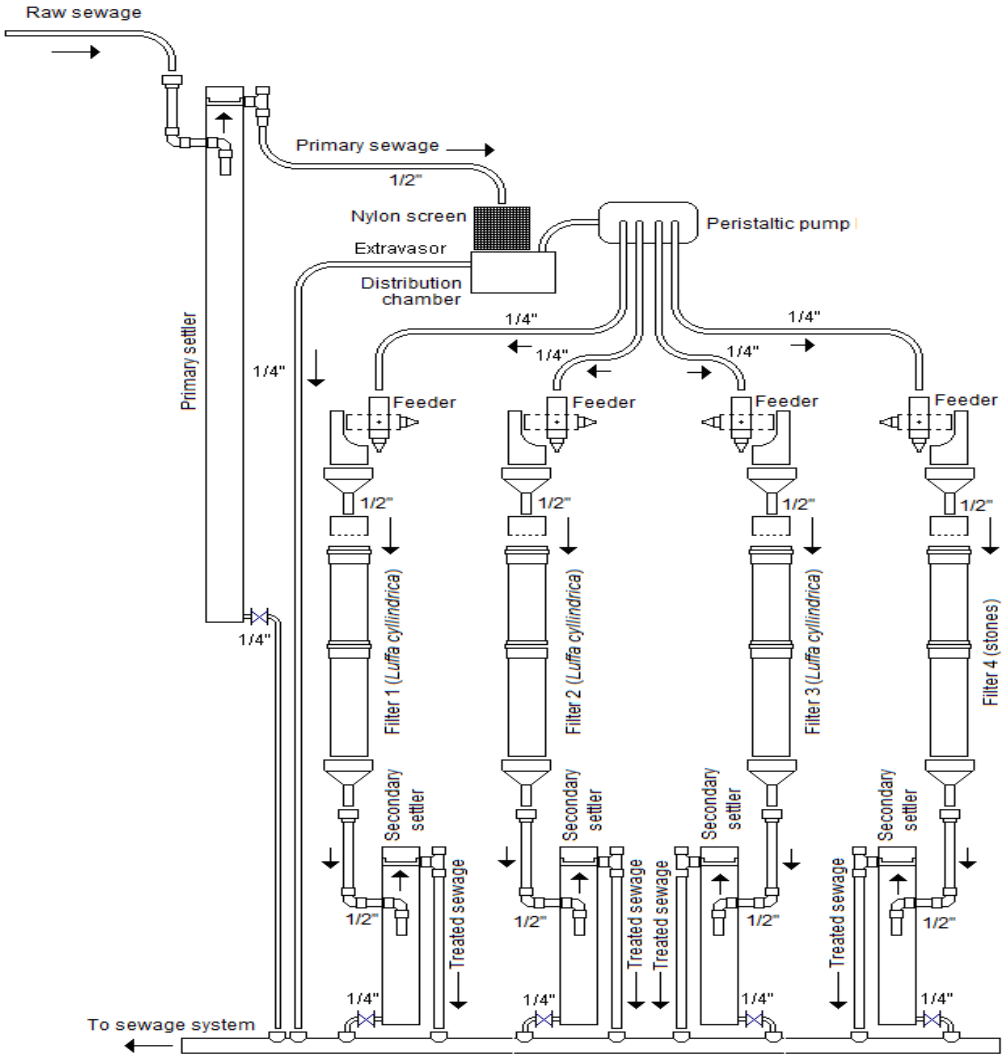


Figure 4 : General arrangement of the pilot plant, consisting of a primary settler, and four parallel and identical secondary biologic systems, three of them operating with *Luffa cyllindrica* as biofilm support medium (F1, F2, F3), and the last one using stones (filter 4).

The experimental treatment process commences after this tank. Free from grit and coarse material previously screened, sewage was conducted to the primary settler through a plastic flexible hosepipe. A fine screen made of nylon (similar to those used in windows to stop mosquitoes) was placed before the hose inlet to avoid clogging.

After primary settling, sewage (now primary sewage) was conducted to a distributing chamber, where another nylon screen was installed. This chamber

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was fed with a flow that was greater than the distributed outflow, therefore its excess was discharged. From this chamber, sewage was distributed and sent to each parallel filter through peristaltic pumps, responsible for the maintenance of a constant flow.

Before reaching the filter, the flow passed through a feeder which converted the continuous flow in pulse hydraulic charges, to simulate what occurs in real trickling filters, which are fed by rotary arms. The hydraulic charge was distributed over the filter surface through a perforated plate installed 20 cm over it.

Each pilot plant was constituted by a 200 mm plastic PVC sewer type pipe. Its interior was filled initially with the supporting medium: peeled and dehydrated Luffa cyllindrica fruits in three of them and 25 mm diameter stones in the fourth. The fruits were initially installed in vertical position. Along the experiment they were cut in sizes that allowed their random disposition inside the columns. No effect was observed because of this change.

The treated sewage after each filter was conducted to secondary settlers and, after that, to the drainage of the laboratory. Considering the average flow sent to each trickling column, equals to 2 mL/s, the hydraulic loading rate was 5,5 $m^3.m^{-2}.day^{-1}$. According to WEF & ASCE (1992), this value can be classified as intermediate rate, which ranges from 0,935 $m^3.m^{-2}.day^{-1}$ 1 to 37, 41 $m^3.m^{-2}.day^{-1}$. Raw and treated sewage samples were collected regularly and analysed in the laboratory of the Environmental and Sanitary Engineering Department of the School of Engineering of UFMG (Table 1).

III. Results

a) Raw sewage charactheristics

Figure 5 represents graphically the obtained results for BOD, COD and TSS, expressed in mg/L. SetS results are expressed in mL/L, so they are not represented in the graphic. Results obtained for these four parameters will be detailed in the following items.

Table 1: Physical, physicochemical and chemical analyses, procedures used and frequency. All analyses were performed as stated by the Standard Methods for the Examination of Water and Wastewater - APHA, AWWA, WEF (1995)

Analysis	Methodology	Frequency
Total suspended solids (TSS)	Gravimetric method	Twice a week
Settleable solids (SetS)	Imhoff cone method	Twice a week
Chemical Oxygen Demand (COD)	Closed flux –Titulometric method	Twice a week
Biochemical Oxygen Demand(BOD5,20)	Iodometric method	Once a week

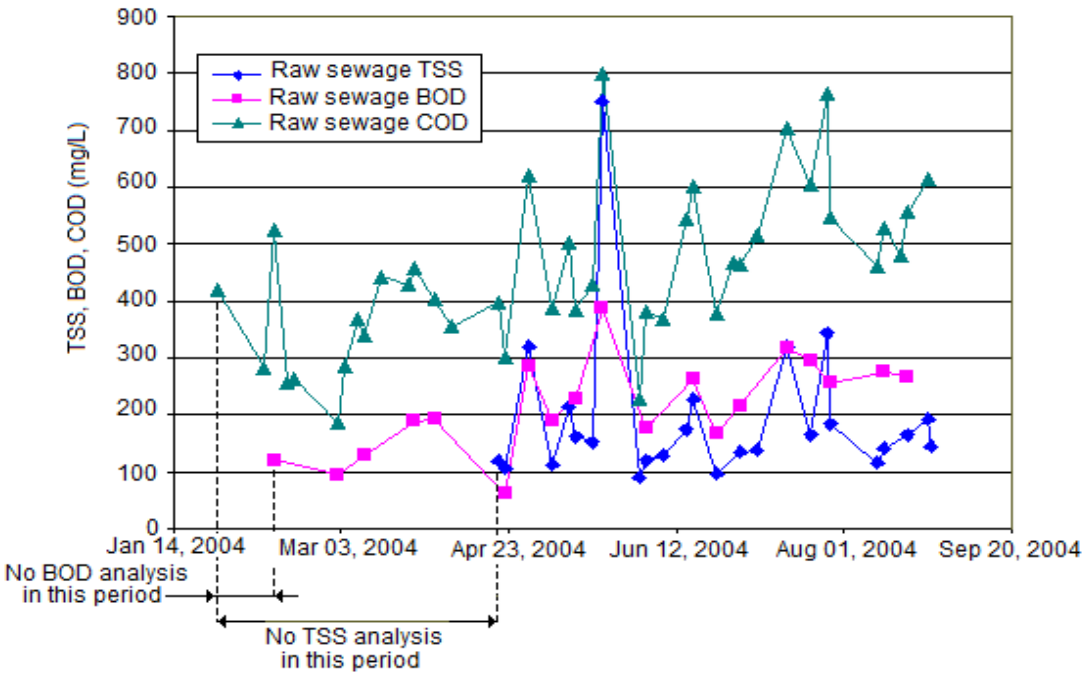


Figure 5 : Temporal series of BOD, COD e TSS contents of the raw sewage.

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b) Biochemical oxygen demand ($BOD_{5, 20}$)

Varied between 61 and 387 $mg.L^{-1}$. The average was 216 $mg.L^{-1}$. After the primary settler it has shown values varying between 61 and 282 mg. L^{-1}. The average for all values was 177 mg. L^{-1}. Percent removal in the primary settler was 18%.

c) Chemical oxygen demand (COD)

Varied between 185 and 601 $mg.L^{-1}$. The average was 451 mg. L^{-1}. After the primary settler it has shown values varying between 168 and 598 mg. L^{-1}. The average for all values was 390 mg. L^{-1}. Percent removal in the primary settler was 14%.

d) Total suspended solids (TSS)

Results were obtained between April 20 2004 and August 27, 2004 and varied between 90 and 752 mg. L^{-1}. The average was 193 mg. L^{-1}. After the primary Settler it was 141 mg. L^{-1}.

e) Settable solids (SetS)

Varied between 0, 10 and 11 $mg.L^{-1}$. The average was 2, 22 mg. L^{-1}. After the primary settler it was 0, 80 mg. L^{-1}.

IV. Performance of the Filters with Respect to Organic Load Reduction

Although the following items contemplate only the $BOD_{5, 20}$ and COD reduction obtained in he experimental work, the variations in the concentrations of total suspended solids and settleable solids were also determined. Also, the $BOD_{5, 20}$ removal efficiency was compared to the efficiencies predicted by some classic formulas used for trickling filters design. These additional data can be found in Vianna (2012).

a) $BOD_{5,20}$ removal

Results obtained upstream the secondary settler are shown in Figure 6 and Figure 7 shows the statistical analysis and the corresponding box-whisker graphics. The average value downstream the *Luffa cyllindrica* filters was 58 $mg.L^{-1}$, while the average value downstream the filter filled with stones was 79 $mg.L^{-1}$.

Results obtained downstream the secondary settler are shown in Figure 8 and Figure 9 shows the statistical analysis and the corresponding box-whisker graphics. The average value downstream the secondary settlers after the *Luffa cyllindrica* filters was 43 mg/L, while the average value downstream the secondary settlers after the filter filled with stones was 57 $mg.L^{-1}$.

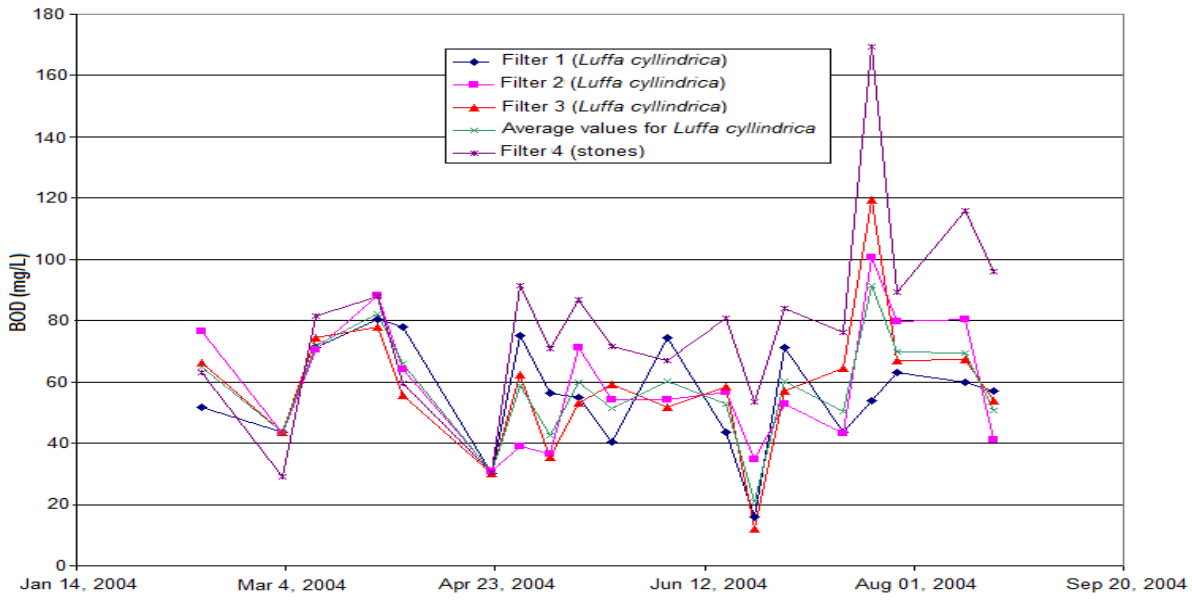


Figure 6 : Biochemical oxygen demand ($BOD_{5, 20}$) downstream the trickling filters filled with *Luffa cyllindrica* (F1, F2, F3 and average value) and downstream the filter filled with stones (upstream the secondary settlers): temporal series.

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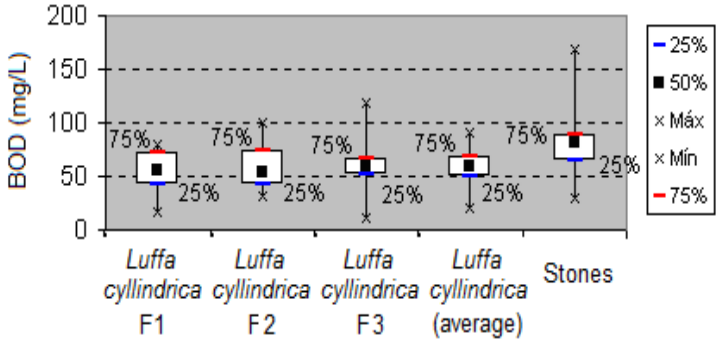


Figure 7 : Box-whisker graphics for biochemical oxygen demand ($BOD_{5,20}$) downstream the filters filled with *Luffa cyllindrica* (F1, F2, F3 and average value) and downstream the filter filled with stones (upstream the secondary settlers).

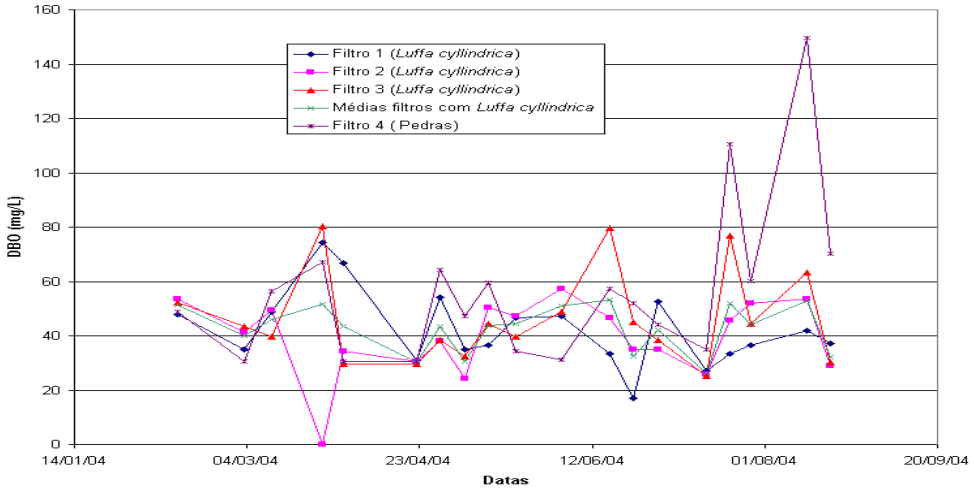


Figure 8 : Biochemical oxygen demand ($BOD_{5,\ 20}$) downstream the trickling filters filled with *Luffa cyllindrica* (F1, F2, F3 and average value) and downstream the filter filled with stones (downstream the secondary settlers): temporal series.

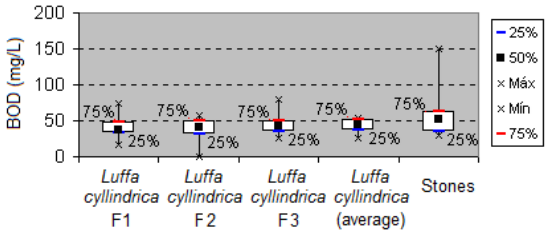


Figure 9 : Box-whisker graphics for biochemical oxygen demand ($BOD_{5,20}$) downstream the filters filled with *Luffa cyllindrica* (F1, F2, F3 and average value) and downstream the filter filled with stones (downstream the secondary) settlers

b) COD remotion

Results are shown in Figure 10 and Figure 11 shows the statistical analysis and the corresponding box-whisker graphics. The average value downstream the *Luffa cyllindrica* filters was 183 mg/L, while the average value downstream the filter filled with stones was 209 mg/L.

Results obtained downstream the secondary settler are shown in Figure 12 and Figure 13 shows the statistical analysis and the corresponding box-whisker graphics. The average value downstream the secondary settlers after the *Luffa cyllindrica* filters was 154 mg/L, while the average value downstream the secondary settlers after the filter filled with stones was 166 mg/L.

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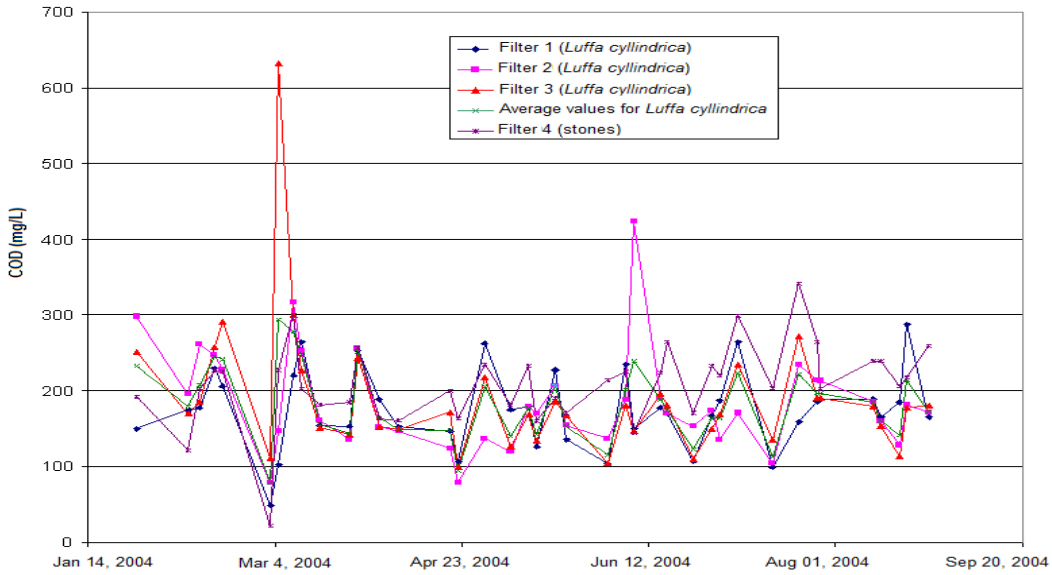


Figure 8 : Chemical oxygen demand (COD) downstream the trickling filters filled with *Luffa cyllindrica* and downstream the filter filled with stones (upstream the secondary settlers): temporal series.

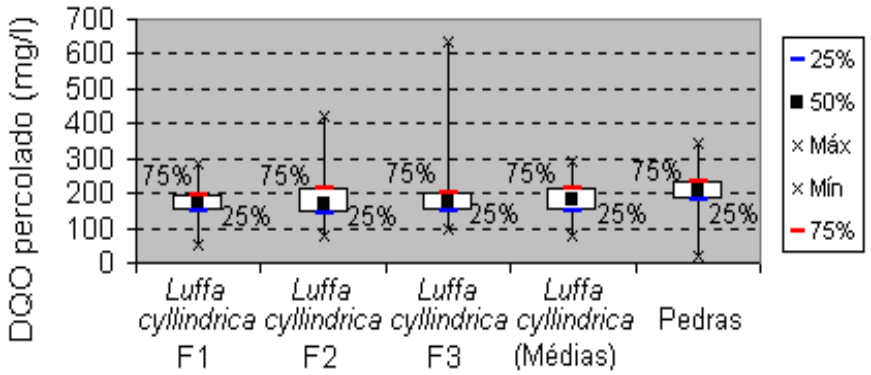


Figure 9 : Box-whisker graphics for chemical oxygen demand (COD) downstream the filters filled with *Luffa cyllindrica* (F1, F2, F3 and average value) and downstream the filter filled with stones (upstream the secondary settlers).

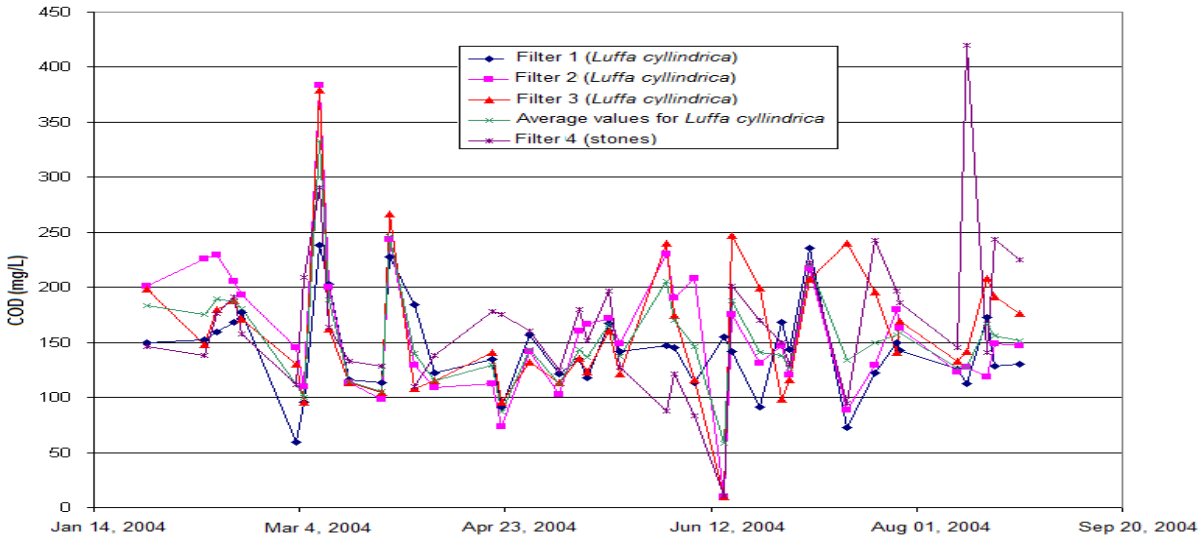


Figure 10 : Chemical oxygen demand (COD) downstream the trickling filters filled with *Luffa cyllindrica* and downstream the filter filled with stones (downstream the secondary settlers): temporal series.

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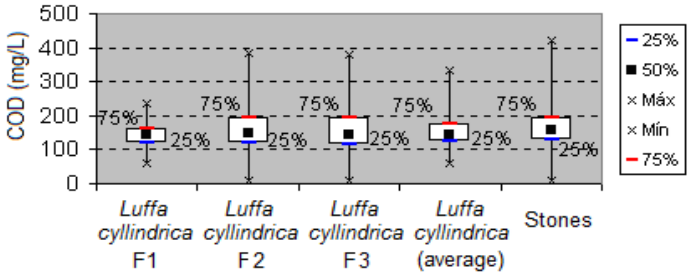


Figure 11 : Box-whisker graphics for chemical oxygen demand (COD) downstream the filters filled with Luffa cyllindrica (F1, F2, F3 and average value) and downstream the filter filled with stones (upstream the secondary settlers).

V. Microbiological Aspects of the Support Medium

Samples of the biomass laying inside the *Luffa cyllindrica* and stone filters were collected and submited to microscopic analysis. Only the first 5 cm depth of the medium surface were investigated. The samples were sent to the hidrobiology laboratory and examined in their qualitative aspects.

a) Luffa cyllindrica support medium

There were found bacteria (figure 12), fungi (figure 13), stalked ciliates (figure 14) and free-living nematodes (figure 15).

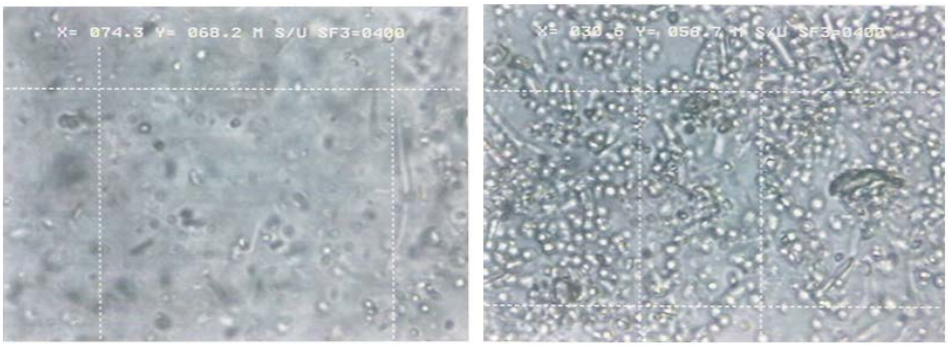


Figure 12 : Biomass found in *Luffa cyllindrica* biomass: bacteria.



Figure 13 : Biomass found in *Luffa cyllindrica* biomass: fungi of the genus Geotrichum

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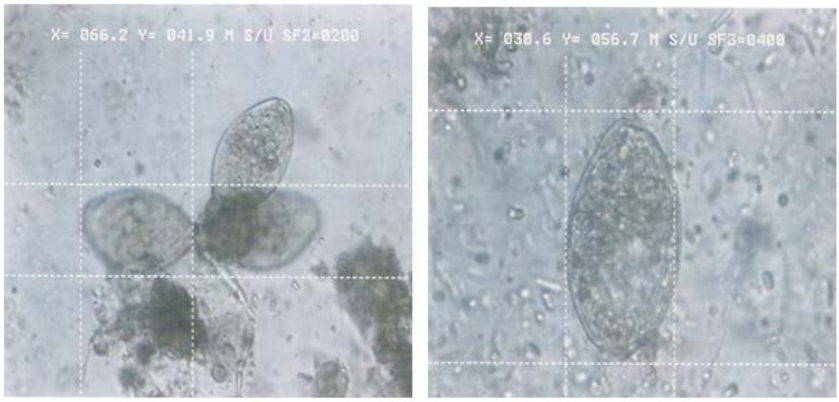


Figure 14 : Biomass found in *Luffa cyllindrica* media: fixed or stalked ciliates (left) and stalked without stalk (right).

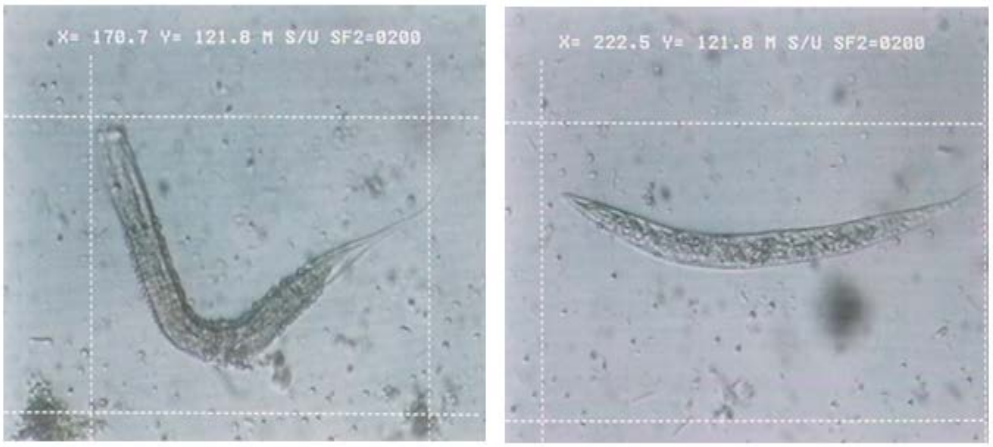


Figure 15 : Biomass found in *Luffa cyllindrica* media: nematode

b) Stones support media

In this support media only bacteria (figure 19) and fungi (figure 20) were found.



Figure 19 : Biomass found in stones media: bacteria *Sphaerotilus natans*.

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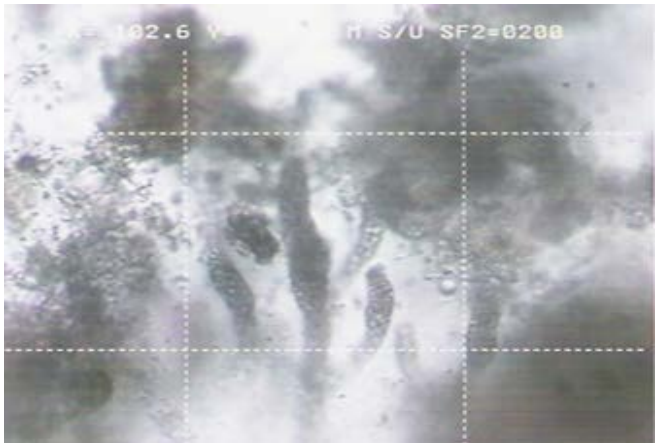


Figure 20 : Biomass found in stones media: fungos *(Leptomitus)*

VI. Discussion

a) Raw sewage characteristics

From the exposed before and considering the average results, the raw sewage concentration could be classified as medium, see table 2.

Table 2 : Typical composition of domestic sewages, according to Metcalf & Eddy (2003), compared to values obtained in the experimental results

Parameter	Values of literature			Results from the experiment
	Strong	Medium	Weak	
Total suspended solids – TSS ($mg.L^{-1}$)	350	200	100	193
Settleable solids– SetS ($mL.L^{-1}$)	20	10	5	2.22
Biochemical oxygen demand – $BOD_{5,20}$ ($mg.L^{-1}$)	300	200	100	216
Chemical oxygen demand – COD ($mg.L^{-1}$)	1000	500	250	451
: Note: The following relationships can be obtained from values above:				
COD/BOD ratio	3,3	2,5	2,5	2,1
Relação TSS/BOD ratio	1,17	1	1	0.9

Lower values obtained for BOD, COD and TSS occurred in the rainy period of the year, while higher values occurred in the dry period, thus reflecting the infiltration of storm water in the sanitary sewers.

On the other hand, lower values obtained for SetS occurred in the dry period of the year, while higher values occurred in the rainy period. It is interesting to observe the inverse tendency of this parameter when compared to the others. Settleable solids were higher when sewage was diluted, probably because of the entrance of inert material brought by storm water that entered into the sewer system, whereas the other parameters representing the organic

b) Performance of the filters with respect to solids and organic load reduction

It is important to note that during the essays it was observed that the fibrous structure of the dehydrated fruits lost volume continuously, and the height of the filter medium decreased steadily, and it was necessary to restore the filter medium every month by adding fresh peeled fruits in the upper part of the reactor, to restore the original height. In spite of the thickening of the structure, no loss of efficiency of the process was observed.

c) Biochemical oxygen demand ($BOD_{5,20}$)

The average percentage removal efficiencies of the filters relative to the primary sewer obtained along the whole observation period were:

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Filters filled with *Luffa cyllindrica*: $\left(100\frac{177-58}{177}\right)\% = 67\%$

Filter filled with stones: $\left(100\frac{177-79}{177}\right)\% = 55\%$

When the results downstream the secondary settlers are considered, the average removal efficiencies relative to the primary sewer along the whole observation period were:

Filters filled with *Luffa cyllindrica* followed by secondary settlers: $\left(100\frac{177-43}{177}\right)\% = 76\%$

Filter filled with stones followed by secondary settlers: $\left(100\frac{177-57}{177}\right)\% = 68\%$

When the whole system is considered, from the raw sewage until the exit of the secondary settler, the average removal efficiencies along the observation period were:

Filters filled with *Luffa cyllindrica* followed by secondary settlers: $\left(100\frac{216-43}{216}\right)\% = 80\%$

Filter filled with stones followed by secondary settlers: $\left(100\frac{216-57}{216}\right)\% = 74\%$

d) Chemical oxygen demand (COD)

The average of chemical oxygen demand (COD) percentage removal efficiencies of the filters relative to primary sewer along the whole observation period were:

Filters filled with *Luffa cyllindrica*: $\left(100\frac{390-183}{390}\right)\% = 53\%$

Filter filled with stones: $\left(100\frac{390-209}{390}\right)\% = 46\%$

When the results downstream the secondary settlers are considered, the average removal efficiencies relative to primary sewer obtained along the whole observation period were:

Filters filled with *Luffa cyllindrica* followed by secondary settlers: $\left(100\frac{390-154}{390}\right)\% = 61\%$

Filters filled with stones followed by secondary settlers: $\left(100\frac{390-166}{390}\right)\% = 57\%$

When the whole system is considered, from the raw sewage until the exit of the secondary settler, the average removal efficiencies along the observation period were:

Filters filled with *Luffa cyllindrica* followed by secondary settlers: $\left(100\frac{451-154}{451}\right)\% = 66\%$

Filter filled with stones followed by secondary settlers: $\left(100\frac{451-166}{451}\right)\% = 63\%$

VII. Microbiologic Considerations

a) Luffa cyllindrica support medium

There were found more species in *Luffa cyllindrica* than in stones media, which can be indicative that the degree of stabilization of the organic matter in more evoluted in the first one. As described, not only bactéria and fungi were found: also stalked ciliates and free-living nematodes were present. The presence of these representatives of the animal kingdom, not

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presente in the samples collected in the biomass encountered in the stones media, seems to show that there is a greater complexity of the food chain and, thus, a more advanced stage. This can probably explain the greater degree of the organic content stabilization obtained in this support media.

Bacteria population, which species were not identified in this work (exception for *Sphaerotilus natans*), are obligatory presence in media where organic stabilization occours. The same is valid for fungi, noting that the genus gênero *Geotrichum* can be found both in soils and sewage (ROSE & HARRISON, 1987). Regarding to the stalk ciliates, whih genus was not identified, their presence was expected n the superficial layers of the trickling filters, as afirmed by Branco (1978). This auhor also states that the presence of worms, such as nematodes, would be expected, as confirmed in this work.

b) Stones support media

In opposition to what eas described above, in this support media there was not found great diversity of species. As described, oly bacteria and fungi were observed, which can indicate lower complexity of the food chain and therefore a less evoluted stage when compared to what happened in *Luffa cyllindrica* media. The less elevated degree of stabilization of the organic content observed in the stones media seems t comprove this hypothesis.

VIII. Conclusion

The study showed that, for specific conditions, the peeled dehydrated fruit of *Luffa cyllindrica* can be used as support medium in trickling filters.

A comparison between the results obtained for the studied parameters and the values allowed by COPAM – the environmental agency of Minas Gerais State, Brazil (MINAS GERAIS, 2008) is presented below. It shows that trickling filters that use *Luffa cyllindrica* as support media can be a suitable and sustainable alternative for domestic sewage treatment in this state.

- ✓ The average value allowable for biochemichal oxygen demand ($BOD_{5,\ 20)}$ in liquid effluents is 60 mg/L. The average value in the treated sewage downstream the *Luffa cyllindrica* systems was 43 mg. L^{-1}. It is also lower than the value obtained downstream the stone system, which was 57 mg.L^{-1}.
- ✓ The average value allowable for chemichal oxygen demand (COD) in liquid effluents is 180 mg. L^{-1}. The average value in the treated sewage downstream the Luffa cyllindrica systems was 154 mg. L^{-1}. It is also lower than the value obtained downstream the stone system, which was 166 mg. L^{-1}.

When considreing anyone of the two parameters above, the performance of the filters containing *luffa cyllindrica* was superior to the filter containing stones.

Although it was not a specific purpose of this study, it was observed that the biofilm formed in the filters containing *Luffa cyllindrica* presented greater diversity of genus and and superior evolutive stage to those found in the filter containing stones.

IX. Recommendations

The experiments here described were conducted in pilot filters of small dimensions inside a laboratory facility. They have been protected along the whole experimental period against many external conditions that could interfere in the process, such as: direct exposition to sunlight, greater variations of temperature, exposition to rain, among others. Thus, a similar experimental work in open field and using larger filters would be the natural next step for further investigations.

The internal dimensions of the reactors did not allow the conduction of a study on efficiency versus height of the medium. So, this is also an important experimental work to be done.

Another investigation to be recommended is the assessment of the physical stability of the peeled dehydrated fruit during time it remains in activity, when the biofilm is installed over their fibrous structure and some liquid is retained inside its void spaces. In order to lower the cost of the installation of trickling filters, it would be desirable that the filling medium could be self-sustainable, so the walls of the filter could be of no structural nature.

An investigation on efficiency as a function of the hydraulic loading rate is also recommended, besides the treatment capacity as a function of the organic loading rate, and possible effects of recirculation.

X. Acknowledgments

We thank COPASA – Companhia de Saneamento de Minas Gerais for the grants and financial support provided. The contribution of the undergraduate students Adriana S. Ito, Fábio J. Bianchetti, Lorenzo Amaral, and Rodrigo M. Oliveira for the experimental work is also acknowledged.

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Neuro-Dynamic Optimization of Biotechnological Process

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Abstract- In this paper we have investigated the whey fermentation at the production of white brine cheese with strain Kluyveromyces marxianus lactis MC 5, using non-conventional substrate whence for receiving of unicellular protein by an ecological clean and wasteless technology. This process is used for dynamic optimisation Neuro-Dynamic Programming theory. With this optimization procedure the quantity product is increased at the end of the process, simultaneously fermentation time is decreased. The producing of lactose with using of cheese whey, which is a waste product at the production of white brine cheese leads to the receiving one of close cycle and an ecological clean and wasteless technology.

Keywords: *neuro-dynamic programming, whey fermentation.*

GJSFR-E Classification : *FOR Code : 27089*



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Neuro-Dynamic Optimization of Biotechnological Process

Tatiana Ilkova [α] & Mitko Petrov [σ]

Abstract- In this paper we have investigated the whey fermentation at the production of white brine cheese with strain *Kluyveromyces marxianus lactis MC 5*, using non-conventional substrate whence for receiving of unicellular protein by an ecological clean and wasteless technology. This process is used for dynamic optimisation Neuro-Dynamic Programming theory. With this optimization procedure the quantity product is increased at the end of the process, simultaneously fermentation time is decreased. The producing of lactose with using of cheese whey, which is a waste product at the production of white brine cheese leads to the receiving one of close cycle and an ecological clean and wasteless technology.

Keywords: neuro-dynamic programming, whey fermentation.

I. Introduction

Dynamic Programming (DP) is an method for optimization and optimal control that has applied to surmount these restriction. The irnteest in this approach is due to the fact that too many hypotheses are based on the analytical structure of the equations, system and criteria. Therefore, it is possible to develop algorithms for solution of the optimal control problems independently of the used model and optimization criterion. DP should be applied parameterize the optimal decision as a function of the system state. Unfortunately, from the very beginning it was apparent that an increase of the dimensionality of the problem, i.e. an addition of reservoirs, caused an exponential increase in the time required to find a decision. This conducts to the "curse of dimensionality" (Bertsekas & Tsitsiklis, 1996).

Neuro-dynamic programming (NDP) is suggested as an alternative to lighten the *"curse of dimensionality" of the DP. NDP is a contemporary approach of the dynamic programming methods for optimization and optimal control and decision making under uncertainty. NDP combines ideas from the scopes of neural networks, artificial intelligence, reinforcement learning cognitive science, simulation, and approximation theory (Driessens &. Dzeroski, 2004).*

Using common artificial intelligence terms, the methods allow the systems to "learn how to make good decisions by observing their own behavior and use built-in mechanisms for improving their actions through a reinforcement mechanism". In more mathematical meaning "observing their own behavior" relates to simulation and "improving their actions through a reinforcement mechanism" relates to the iterative schemes for improving the quality of approximation of the optimal cost function, the Q-factors or the optimal policy. There has been a gradual realization that the reinforcement learning techniques can be fruitfully motivated and interpreted in terms of classical DP concepts such as the value and policy iteration, (Sutton, 1988).

The optimal control of this process usually depends on the presence of complex, non-linear dynamic model of the system because of this is difficult to realize to working-out of the problem, which is very important to practical realize.

The general disadvantage in optimization and optimal control methods of the bioprocesses is that the fermentation finishing time should be fixed. When we want to find the optimal fermentation finishing time, many various fermentation finishing times should be assumed, for each one of them, an efficiency optimal control problem should be determined. This is an extremely demanding task in terms of calculations. Approach such as control parameterisation can be used for free-end-time tasks to obtain open loop optimal profiles. Another hindrance of these approach checks from the circumstance that they are open loop optimal, which signifies that each time an initial condition shifts, a new and different optimal control problem should be determined. Moreover, the resulting fixed strategies do not take into advantage the likely process disturbances (Vlachos et. all 2006), (Lewis & Derong, 2013).

The fermentation of lactose oxidation from natural substratum in fermentation of Kluyveromyces marxianus lactis MC 5 uses non-conventional whence for receiving of unicellular protein. This process is not well studied. Therefore it does not exist a general mathematical model of the microbial synthesis, because of the extreme complexity and great variety of living activity of the microorganisms, although various models of biotechnological process and of different parts of the whey fermentation exist. On this cheese whey, which is waste product at the production of white brine cheese, oneself with what oneself reception one close cycle (Nono et. all 2006).

The aim of this study is to develop optimal feed rate strategy of biotechnological process in whey fermentation using Neuro-dynamic control.

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II. Mathematical Model of the Process

Six fermentations were carried out in aerobic batch cultivation of Kluyveromyces lactis. A laboratory bioreactor ABR 02M with capacity 2 l has been used. The strain Kluyveromyces marxianus lactis MC5 is cultivated under the following conditions (Anastassiadis, 2007):

1. Nutrient medium with basic component – whey ultra filtrate with lactose concentration 44 g/l. The ultra filtrate is derived from whey separated in production of white cheese and deproteinisation by ultra filtration on LAB 38 DDS with membrane of the type GR 61 PP under the following condition:

- T=40-43 °C;
- input pressure 0.65 MPa;
- out put pressure 0.60 MPa.

The ultra filtrate is used in native condition with lactose concentration 44 g/l. Nutrient medium consist of:

- (NH) 4HPO 0.6%;
- yeast's autolisate 5%;
- yeast's extract 1%;
- pH 5.0 - 5.2.

2. The air flow rate QG is 60 l/l/h up to the 4th hour and 120 l/l/h up to the end of the process under continuous mixing n=800 min-1.
3. Temperature is 29 °C.
4. Duration of the cultivation is tf=12 hours.

The following figure describes the mass balance of the pressed-dough cheese and whey drink process.

The changes of the microbiological process (lactose conversion in yeast's cells to protein) are studied during the strain growth:

a) lactose concentration in fermentation medium in oxidation and assimilation of lactose by Kluyweromyces Marxianus lactis MC5 is determined by enzyme methods by UV tests (Boehringer Manheim, Germany, 1983);
b) concentration of cell mass and protein contents are determined on the basis of the nitrogenium contents (Kjeltek system 1028);
c) concentration of the dissolved oxygen in the fermentation medium in the process of oxidation and assimilation of lactose is determined by oxygen sensor.
d) For the measurement of the oxygen concentration in the fermentation middle the oxygen sensor that is produced by LKB firm, is used.

Six fermentations where carried out in aerobic batch cultivation of Kluyveromyces lactis. The experimental investigations are carried out on the computer controlled laboratory bioreactor 2L-M with magnetic coupling.

The model of the batch processes includes the dependences between the concentrations of the basic variables of the process: cell mass concentration, substrate concentration and oxygen concentration in the liquid phase:

$$\frac{dX}{dt} = \mu(S, C_L)\, X$$
$$\frac{dS}{dt} = -Y_1\, \mu(S, C_L)\, X \qquad (1)$$
$$\frac{dC_L}{dt} = \frac{k_l a}{1-\varepsilon_G}\left(C^* - C_L\right) - Y_2\, \mu(S, C_L)\, X$$

Where:

$$\mu(S, C_L) = \mu_m \frac{S^2}{\left(k_S + S^2\right)} \frac{C_L}{\left(k_C + C_L + C_L^2 / k_i\right)}$$

$\mu(S,C_L)$–specific grown rate of the cells, h^{-1}; μ_m - maximal rate of the cells, h^{-1}; X–cell mass concentration, g/l; S–concentration of substrate, g/l; C*–mean oxygen concentration, g/l; CL–dissolved oxygen concentration in liquid phase, g/l; kla–volumetric mass transfer coefficient, h^{-1}; ε_G–gas hold up; k_S, k_C, k_i, Y_1 and Y_2–coefficients; t–time, h.

The initial conditions and coefficients in model are given as follows:

X (0) = X0=0.2 g/l; S (0) = S0=44 g/l; CL (0) = C0=6.0x10-3 g/l; C*=C0, g/l;
μ_m =0.89; k_S=1.62; kC=3.37x10-3; kI=0.47; Y_1=2.238 and Y2=3.24x10-3.

The mass transfer coefficient kla and gas hold-up are determined by:

$$k_l a = 52\left(P/V\right)^{0,38} W_G^{0,23},\ \varepsilon_G = 0.53\left(Q_G/(nd^3)\right)^{-0.014} \qquad (2)$$

where: P–power input, $P = 60.9\rho n^3 d^5 \mathrm{Re}^{-0.4}$, W; V–volume, m3; ρ–liquid density, kg/m3; n–agitation speed, s-1; d–impeller diameter, m; Re–Reynolds number; WG–gas velocity, $W_G = 4\,Q_G/\pi\, D^2$, m/s; QG–air flow rate, m3/s; D–bioreactor diameter, m.

The model of the process (1)-(2) is used for optimization of batch fermentation of lactose oxidation from natural substratum in fermentation of the strain Kluyveromyces marxianus lactis MC 5.

III. Optimization of Fermentation Process

For determination of the optimal control problem of fed-batch fermentation processes maximizing of the optimization criterion at the end of the process max J on

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the used substrate S is accepted. Thus the optimization problem is reduced to find a profile of the control variable.

The optimization criterion is accepted the value of the functional X (t) at the end the process (T=12) that means of the quantity formed biomass after 12 hour fermentation.

The criterion of quality has a type:

$$\max_{\mathbf{u}} Q = \int_{t_0}^{t_f} X(t)V(t)\,dt$$

where: t_0 – initial time, t_f – final time of the fermentation. The objective of this work is to find the optimal feed flow rate (F(t)) of a fed-batch process, such as the biomass, that will raise the biomass at the end of the process, i.e.:

$$\max_{\mathbf{u}} Q = \int_{t_0}^{t_f} X(t)V(t)\,dt \qquad (3)$$

A general dynamic optimization problem can be defined as follows:

$$\max_{\mathbf{u}_0,\ldots,\mathbf{u}_{k-1}} \sum_{i=1}^{k-1} f\,(\mathbf{W}_i, \mathbf{u}_i) \qquad (4)$$

Where: W is a vector of the variables that describe process, u - vector of control variables, k is the current stage.

The objective is to maximize the combination of the total span and the stagewise, together with the terminal costs subject and the terminal constrains.

DP includes a stagewise calculation of the cost-to-go function to reach the solution for the general initial state. The cost-to-go (10) at each stage is defined by (*Anastassiadis,* 2007):

$$B_i\left(W(t_i), t_i\right) = \max_{u_{\min} \le u_k \le u_{\max}} \Delta t \sum_{k=1}^{N-1} f_k\left(\mathbf{W}_k, \mathbf{u}_k\right) \qquad (5)$$

Then the calculation of the cost-to-go function at each stage can be done as:

$$B_i\left(W(t_i), t_i\right) = \max_{\mathbf{u}_{\min} \le \mathbf{u}_k \le \mathbf{u}_{\max}} \left\{ f_i\left(W(t_i), \mathbf{u}_i\right) + B\left(W(t_{i+1}), t_{i+1}\right) \right\} \qquad (6)$$

Once obtained the cost-to-go function, represents a convenient vehicle to obtain the optimal solution for the general stage.

By continuing the cost-to-go iteration of (6) until convergence within the procedure it can be seen that the infinite horizon cost-to-go function B_∞, satisfying the following "Bellman equation" can be obtained:

$$B_\infty(W) = \max_{\mathbf{u}} \left\{ f(W, \mathbf{u}) + B(W, \mathbf{u}) \right\} \qquad (7)$$

Unfortunately, in very few cases the problem can be solved through the stagewise optimization in order to analytically obtain a closed-form expression for the cost-to-go problem. The conventional numerical approach to the problem involves gridding the state space, calculating and storing the cost-to-go for each grid points as one marches backward from the first (or last) stage to the lest (first). For an invite horizon problem the number of iterations required for convergence can be very big. Such an approach is seldom practically feasible due to the exponential growth of the computation with respect to the state dimension.

The traditional approach for solving the Bellman equation involves gridding of the state space, solving the optimization (10) for each grid point and performing the stagewise optimization until convergence is achieved. The comprehensive sampling of the state space can be avoided by identifying the relevant regions of the state space by simulation under judiciously chosen suboptimal policies (Vlachos et. al. 2006).

The policy improvement theorem states that a new policy that is greedy (a greedy policy is one whose current cost is the least) with respect to the cost-to-go function of the original policy is as good as or better than the original policy, so the new policy can be defined as follows:

$$\mathbf{u}(W) = \arg\max_{\mathbf{u}} f\ (\mathbf{W}, \mathbf{u}) + B(\mathbf{W}, \mathbf{u})$$

Where $\arg\ G(u, x, i) \in R_{m+n+r}$ is an improvement over the original policy and $u \in R_m$, $W \in R_n$ and $i \in R_r$.

When the new policy is as good as the original policy the above equation becomes the same as Bellman equation (7).

The relevant regions of the state space are identified by simulation of NDP control and the initial suboptimal cost-to-go function is calculated from the simulation data. In this survey a functional approximator is used to interpolate between this data. The improvement is obtained through the iteration of the Bellman equation. When the iteration Converge this off-line computed cost-to-go function can be used for an on-line optimal control calculation for the bioreactor (Xiong & Zhang, 2005).

NDP uses neural network approximations for the approximation of cost-to-go function. The cost-to-go function was not used to generate an explicit control law; instead, it was used in an on-line optimization to reduce the large (or infinite) horizon problem to a relatively short horizon problem. The method was found to be robust to approximation errors. Both deterministic (step changes in kinetic parameters) and stochastic problems (random variations in kinetic parameters and feed composition) were explored (Peroni et. all 2009), (Krishnamoorthy K. et al 2011).

The following notations are used for description of the algorithm:

B – Bellman equation;

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$\widetilde{B}(x)$ - approximated Bellman equation corresponding to state W;

$()^i$ – iteration index for cost iteration loop;
k – discrete time.
Finally:

$$\widetilde{B}(k) \equiv \widetilde{B}(W(k)) \text{ and } f(k) = f\big(W(k), \mathbf{u}(k)\big)$$

The general simulation-approximation scheme involves computation of the converged cost-to-go approximation off-line. The architecture of the scheme is shown in Figure 2. Step 1, Step 2, Step 3 and Step 4 represent the "Simulation part", and 5 and 6 the "Cost Approximation Part".

The simulation-based approach involves computation of the converged profit-to-go approximation off-line. The following steps describe the general procedure of NDP algorithm:

1. Starting with a given policy (some rule for choosing a decision u at each possible state i), and approximately evaluate the cost of that policy (as a function of the current state) by least-squares-fitting a scoring function $\widetilde{J}^j(X)$ to the results of many simulated system trajectories using that policy;
2. The solution of one-stage-ahead cost plus cost-to-go problem, results in improvements of the cost values;
3. The resulting deviation from optimality depends on a variety of factors, principal among which is the ability of the architecture $\widetilde{J}^j(X)$ to approximate accurately the cost functions of various policies;
4. Cost-to-go function is calculated using the simulation data for each state visited during the simulation, as for each closed loop simulation (simulation part).
5. A new policy is then defined by minimization of Bellman's equation, where the optimal cost is replaced by the calculated scoring function, and the process repeats. This type of algorithm typically generates a sequence of policies that eventually oscillates in a neighbourhood of an optimal policy;
6. Fit a neural network function approximator to the data to approximate cost-to-go function as a smooth function of the states;
7. The improved costs are again fitted to a neural network, as described above, to obtain subsequent iterations $\widetilde{J}^1(X), \widetilde{J}^2(X)$, and so on …, until convergence.

The NDP algorithm block- scheme is shown in Figure 1.

Take into consideration that when starting with a fairly good approximation of the cost-to-go (which has to be a result of using a good suboptimal policy), the cost iteration has to converge fairly fast – faster than the conventional stagewise cost-to-go calculation.

The next values of F are examined - *F=0.1, 0.2, …, 0.7*, that can cover the possible rang of variations.

The bioreactor was started at three different W (0) values for each of the parameter values around the low product yield steady state.

A functional approximation relating cost-to-go with augmented state was obtained by the neural network – with five hidden nodes, six input nodes and two output nodes. The neural network presented a good fit with a mean error of 10-3 after training for 1000 epoch.

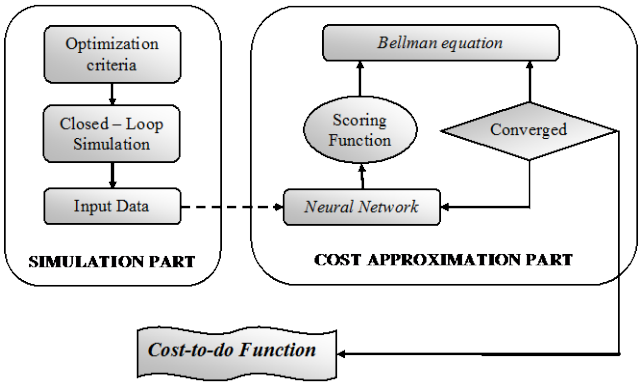


Figure1: NDP algorithm.

Improvement of the cost-to-go is obtained through the iterations of the Bellman equation (13). This method is known as a value iteration (or value iteration). The solution of the one-stage-ahead cost plus cost-to-go problem, results in the improvement of the cost values. The improved prices were again fitted to the neural network, described above to obtain subsequent iterations $\widetilde{B}^1(k)$, $\widetilde{B}^2(k)$ and so on ..., until they are converged. Cost is said to be "converged" if the sum of the absolute error is less than 5% of the maximum cost. The cost is converged in 7 iterations for our system.
The converged cost-to-go function from above was used for solving the one-stage-ahead problem. The choice for switch over the one-stage-ahead of the control variable is calculated by:

$$\mathbf{u}(k) = \arg\max_{\mathbf{u}(k)} \left\{ f\left(\frac{Q(t_k)}{t_k}, \mathbf{u}\right) + \widetilde{B}^6\left(\frac{Q(t_k)}{t_k}, \mathbf{u}(k)\right) \right\} \quad (8)$$

Where: u is vector of control variables, k is the optimization stages, B is Bellman equation.

Following this procedure, a program on MATLAB 8.0 has been developed and the optimal profile of the control variable has been obtained.

With this procedure a program on MATLAB 8.0 is developed and it the optimal profile of the optimal control variables are obtained. The time procedure is in 1100 s. The profile is shown on Figure 2.

The concentration of the biomass before and after optimization is shown in Figure 3.

The program for optimal control is developed using NDP method. The results show generally an

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increase of 13.37 % amount of biomass production after the dynamic optimization. This result is shown in Figure 9.

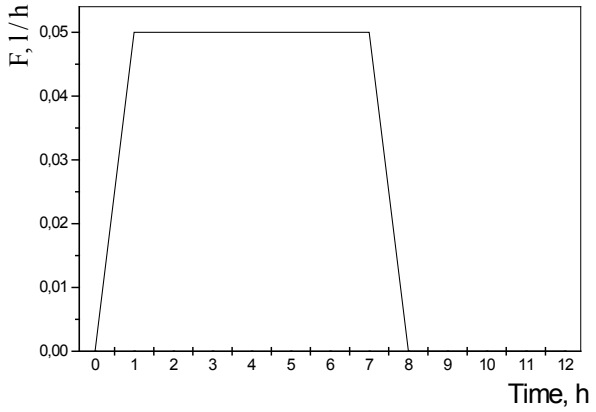


Figure 2 : Optimal profile of the feeding rate received with and NDP.

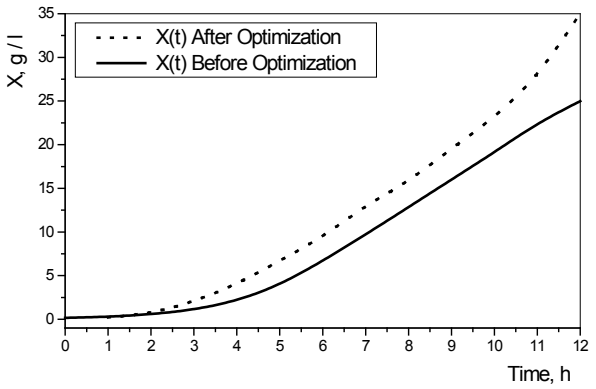


Figure 3 : Concentration of the biomass before and after optimization

IV. Conclusion

A technique based on Neuro-Dynamic Programming approach has been developed to achieve an optimal feed rate profile for biomass production a fed-batch bioprocess.

The approach proposed such as one methodic for alleviation of "curse of dimensionally" of dynamic programming. The results show that quality biomass is risen at the end of the process. Using of the method shows that it to be able for application in on-line optimal problems.

Realization of such an optimal control approach combined with advanced control techniques (artificial neural networks with classical optimization method) in practice can conduct to the value and elaboration time reduction in the laboratory fed-batch bioprocesses, but not only that, as well in elaboration time reduction technique for optimal control.

The producing of lactose with using of cheese whey, which is a waste product at the production of white brine cheese leads to the receiving one of close cycle and an ecological clean and wasteless technology.

V. Acknowledgement

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What is the Most Environmentally-Friendly Utilization of Biomasses?

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Abstract- This article deals with the realistic and effective use of biomass mainly as an energy supply, since the fuel production from crops and other biomass resources has attracted much attention in the world. Several concrete examples of the evaluation of biomass utilization were exhibited from two different standpoints. One was "qualitative" evaluation, which includes the ratio of input/output energy, a new index of CO_2 emission reduction, the comparison of the electricity generation density using solar energy, and the energy efficiency of cars with different source of power. The other was "quantitative" evaluation, which means the amount and distribution of readily-utilizable biomass resources and a comparison between the supply and demand of these resources. In conclusion, it was emphasized that the priority of biomass use should be as follows according to its economical value: human food is greater than animal feed, which is greater than industrial material, which is greater than fuel (energy). Thus, the cascade-type biomass utilization system should be sought; in addition, biomasses should be used as a local energy source, not as an alternative to petroleum.

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What is the Most Environmentally-Friendly Utilization of Biomasses?

S Matsuda

Abstract- This article deals with the realistic and effective use of biomass mainly as an energy supply, since the fuel production from crops and other biomass resources has attracted much attention in the world. Several concrete examples of the evaluation of biomass utilization were exhibited from two different standpoints. One was "qualitative" evaluation, which includes the ratio of input/output energy, a new index of CO_2 emission reduction, the comparison of the electricity generation density using solar energy, and the energy efficiency of cars with different source of power. The other was "quantitative" evaluation, which means the amount and distribution of readily-utilizable biomass resources and a comparison between the supply and demand of these resources. In conclusion, it was emphasized that the priority of biomass use should be as follows according to its economical value: human food is greater than animal feed, which is greater than industrial material, which is greater than fuel (energy). Thus, the cascade-type biomass utilization system should be sought; in addition, biomasses should be used as a local energy source, not as an alternative to petroleum.

I. Introduction

Recently, the liquid fuel production from crops and other biomass resources ('biofuel') has attracted much attention in the world as the prevention of global warming is becoming an urgent issue, because the biofuel is perceived to be 'carbon neutral' and useful as a countermeasure against global warming.

In fact, the production of biofuel has been put into practical use not only in the US, EU, Brazil and other countries but also in Japan. As for its impact on the environment, however, evaluations still vary, including those concerning the influence of biofuel on the global economy, for example the food price crisis that might have been caused by competition within the food industry. In the previous study [1], the author pointed out that 'bio-ethanol' from crops is never 'carbon neutral' nor is it useful as a countermeasure against global warming.

Since the shortage of food crops affected by the expansion of biofuel production became a critical issue, the 'second-generation' of biofuel made from non-food biomass sources has attracted much attention all over the world. In particular, the following statement in the Hokkaido Toyako G8 summit held in Nov. 2008 accelerated this trend which made 'use of biofuels with food security and accelerated the development and commercialization of sustainable second-generation biofuels from non-food plant materials and inedible biomass' (in 'G8 Leaders Statement on Global Food Security' [2]).

The target biomass contains a wide variety of types: cellulosic materials, such as woody biomasses, and paddy straw, algae and some kinds of oil producing plants, which are considered to be sustainable. Research on the kinds of the target biomass is in progress. Among them, 'Jatropha' has emerged as one of the best candidates for future biodiesel production [3]. However, no positive results of an assessment on the validity of Jatropha production were obtained from previous research, in which a feasibility study was attempted as quantitatively as possible using the data obtained from a field survey in Indonesia conducted by the author in January and March of 2009 [4].

In this study, several concrete examples of the evaluation of biomass utilization were exhibited from two different standpoints. One was "qualitative" evaluation, which includes the ratio of input/output energy, a new index of CO_2 emission reduction, the evaluation of the electricity generation density using solar energy, and the energy efficiency of cars using alternative sources of power. The other was "quantitative" evaluation, which involves the amount and distribution of readily-utilizable biomass resources and a comparison between the supply and demand of these resources.

II. "Qualitative" Estimation

In this section, several concrete examples of the evaluation of biomasses were exhibited using the concepts of energy balance (the comparison of input and output), energy production density, and energy utilization efficiency, which were classified as "qualitative" estimation because the basis of the analysis was not an absolute amount but a unit amount per area, energy production, and so on. Most data used in this study were excerpted from references [5] and [6] written by the author.

a) The ratio of input/output energy "μ" and the index of CO_2 emission reduction "ν"

The ratio of energy output to input "μ" has long been used as an index of the utility of energy production systems. In the case of biofuel production, this index is defined as follows:

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$$\mu = \text{(Lower calorific value of biofuel)} / \text{(Total energy input for biofuel production)} \quad (1)$$

The total energy input should contain all kinds of artificial energy input required for biofuel production, such as collection, transportation, cultivation (in the case of cultivated biomasses), and processing. If the biofuel production is valid as an energy supplier, the condition that μ is greater than 1 should be implemented. However, the value of μ is lower than the unity in many cases because the energy input to obtain biofuel is often larger than the energy obtained from biofuel [1], [5], [6].

When the validity of biofuel production is estimated from the standpoint of the reduction of CO_2 emission, the index μ is inadequate because the emission of CO_2 varies according to the type of energy. Thus, a new index of CO_2 emission reduction "ν" was derived and proposed by the author [1] as follows:

$$\nu = \text{(Net reduction of } CO_2 \text{ emission by biofuel use)} / \text{(Gross reduction of } CO_2 \text{ emission by biofuel use)} = (A - B) / A = 1 - B/A \quad (2)$$

Where A equals kg-CO_2/L-biofuel, the amount of biofuel CO_2 emissions used as an alternative to fossil fuel when the principle of "carbon neutral" is simply applied, and B equals kg-CO_2/L-biofuel, the net amount of biofuel CO_2 emissions used as an alternative to fossil fuel when the energy input for biofuel production was taken into account.

Then, the terms A and B can be represented by the following equations, respectively:

$$A = Qa \times Ef \quad (3)$$

Where Qa equals MJ/L-biofuel, the lower calorific value of biofuel, and Ef equals kg-CO_2/MJ, the CO2 emissions from fossil fuel consumption per unit of energy.

$$B = Qt \times Es \quad (4)$$

Where Qt equals MJ/L-biofuel, the total energy input for biofuel production, and Es equals kg-CO_2/MJ, the CO_2 emissions per unit of energy input.

Since the energy input for biofuel production contains various energy sources that have different basic units of CO_2 emissions, the term Es should be expressed as follows:

$$Es = \Sigma (xi \times Esi) \quad (5)$$

Where Esi equals kg-CO2/MJ, the CO2 emissions of energy source i per unit of energy input, and xi equals −, the distribution ratio of energy source i in the total energy input.

In addition, since the CO_2 emissions per unit of energy are different within each energy source i, a coefficient ε should be defined to express a characteristic of CO_2 emissions of energy sources on the basis of energy sources, such as gasoline.

$$\varepsilon = Es / Ef = \Sigma (xi \times Esi) / Ef = \Sigma (xi \times \varepsilon i) \quad (6)$$

Where εi equals Esi / Ef, an index of CO_2 emission characteristics of each energy input source i.

When gasoline is adopted as the basis, the εi values of major fossil fuels are as follows: gasoline's value equals 1.00, light oil, 1.07, kerosene, 1.04, heavy oil, 1.12, coal, 1.37, and natural gas, 0.81.

From equations (2) to (6), the following expression can be derived:

$$\nu = (A - B) / A = 1 - B/A = 1 - (Qt \times Es) / (Qa \times Ef) = 1 - \varepsilon (Qt/Qa) \quad (7)$$

In the case of biofuel production, the ratio of energy output to input μ defined by Eq. (1) is:

$$\mu = Qa / Qt \quad (8)$$

Thus, from equations (7) and (8), ν can be expressed as a function of μ and ε as follows:

$$\nu = 1 - \varepsilon (1/\mu) \quad (9)$$

Since the value of ε is near unity in the case of petroleum-based fuels as stated above, the value of ν is controlled mainly by μ. When the primary energy composition was taken into account, the value of ε in the case of bioethanol (substitute for gasoline) was 0.87, and that of biodiesel (substitute for light oil) was 0.85 from the calculation using recent energy statistics data from Japan [1]. Therefore, the value of $\varepsilon = 0.9$ can be used as an approximated constant value.

There was much research concerning the energy balance in biofuel production (e.g. [7]-[12]), so that the data of μ could be available with relative ease. The examples of ν values using these data are as follows ($\varepsilon = 0.9$ is assumed).

a. Bioethanol production from sugarcane in Brazil: $\mu \fallingdotseq 7.4$, $\nu \fallingdotseq 0.88$ → Effective at reducing CO_2 emissions
b. Bioethanol production from corn in the U. S.: $\mu \fallingdotseq 1$ (0.89～0.99), $\nu \fallingdotseq 0.1$ → Hardly or not at all effective at reducing CO_2 emissions
c. Biodiesel production from soybeans in the U. S.: $\mu \fallingdotseq 0.76$, $\nu = -0.2$ → Increase in CO_2 emissions
d. Bioethanol production from agricultural products in Japan: $\mu \ll 1$, $\nu \ll 0$ → Significant increase in CO_2 emissions

These results indicated that the production of biofuel was never "carbon neutral" and even increased CO_2 emissions in many cases because the artificial energy input for liquid biofuel was often rather large in comparison to the energy content of biofuels. If

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biomasses are used as an energy source, a simple method such as direct combustion of a solid biomass would be more environmentally friendly and nearly "carbon neutral," because the artificial energy input would be relatively small.

a) Energy Production Density: Solar Cell versus Biomass Power Production

As a means for obtaining electricity from solar energy, a comparison was attempted between solar cells and thermal power generation using a woody biomass as follows:

The average energy production density per unit area S of photovoltaic generation in Japan was 158 kWh/m^2/ year [5].

On the other hand, the data of the current annual increment (yearly increase in the accumulation of woody biomasses) in Japanese artificial forests was 11.1 m^3/ha/year [6]. Supposing that the bulk density of a woody biomass is 0.6 $\times$ 10^6 kg/m^3, the lower calorific value of a woody biomass would be 3.4 $\times$ 10^3 kcal/kg, and the efficiency of thermal power using this biomass would be 30%, and the electricity obtained per unit area W would be as follows:

$$W = (11.1\ m^3/ha/year) \times (10^{-4}\ ha/m^2) \times (0.6 \times 10^6\ kg/m^3) \times (3.4 \times 10^3\ kcal/kg) \div (860/0.3\ kcal/kWh) = 0.789\ kWh/\ m^2/year$$

Thus, S/W equals 158/0.789 = 200, meaning that the solar cell has a much higher energy production density than thermal power generation with a woody biomass as a means for obtaining electricity from solar energy. The essential reason for this result is that biomass production is strictly limited by the efficiency of photosynthesis (solar energy accumulated in biomass / total quantity of solar radiation), which is generally about 1% or less on the basis of the annual average. In addition, the efficiency of thermal power is another handicap. This value is about 40% or more in large-scale, state-of-the-art thermal power plants using fossil fuels, but about 30% or much less in thermal biomass power generation due to both the lower calorific value of biomasses and the smaller scale. Considering the situation stated above, it should be concluded that the direct electricity generation using solar cells has a much greater advantage than any method using a biomass (e.g. thermal power or biomass fuel cells), of which the overall efficiency would inevitably be less than that of photosynthesis, if the purpose is to obtain electricity from solar energy.

b) The Possibility of Artificial Photosynthesis as a means to supply organic resources

Artificial photosynthesis has long been researched as "one of the dreams of chemists," but the efficiency of natural photosynthesis by plants (biomass) is much higher than that of any known artificial ones. The final goal of practical artificial photosynthesis would be to supply organic resources such as foods and fuels using solar energy and CO_2 in the air as a carbon source. There is, however, a complexity involved from the aspect of chemical engineering. The amount of organic carbon consumed by humans is about several (10^9) gigatons (GT) per year, which is currently composed of mainly fossil fuels and biomasses (natural photosynthesis). It is obvious that a massive chemical plant would be required for supplying at least several hundreds of millions (10^8) of tons of organic carbon, which would be necessary as a practical countermeasure against global warming, since the solar energy density is about several hundreds of W/m^2 and the efficiency of artificial photosynthesis would be much less than 1%; in addition, the concentration of CO_2 in the air is about 400 ppm (= 0.04%). It is rather difficult to estimate how large of an area as well as how much cost would be required for such an enormous chemical plant. In other words, it will be some time before organic resources used in our society can be supplied from CO_2 in the air as a carbon source using solar energy. Petroleum and natural gas will most likely remain the main carbon sources, and then coal will probably succeed them (e.g. "C1 chemistry" which is not feasible now mainly due to economical efficiency). In short, natural photosynthesis, i.e. biomass production, is much more efficient as a means of supplying organic resources using solar energy and CO_2 in the air as a carbon source than an artificial one in terms of energy efficiency, economics, and the environmental impact.

c) Energy Utilization Efficiency: Bioethanol versus an electric vehicle

One of the reasons why biofuels attracted much attention was that they were liquid fuels and could be used for automobiles directly. For this reason, a comparison in overall energy efficiency should be conducted between cars driven with electricity (motor) and biofuels (internal combustion engine) using the same fuel source of 1 ton of a woody biomass, of which the lower calorific value is 3.4 $\times$ 10^6 kcal/t.

i. *Case 1: Bioethanol production → an internal combustion engine car*

Supposing that the yield of bioethanol from a woody biomass is 290 L/t (rather optimistic) and the lower calorific value of ethanol is 5057 kcal/L, the obtained energy would be 1467 $\times$ 10^3 kcal/t (=5057 kcal/L $\times$ 290 L/t). The gross energy yield without a processing energy input is about 43% (1467 $\times$ 10^3 kcal/t) divided by (3.400 $\times$ 10^3 kcal/t). The energy input for the ethanol producing process would be at least 20% of the energy empirically contained in the biomass material. Thus, the net energy yield would be about 23%. Also, if the efficiency of an internal combustion engine using bioethanol is 16%, then the overall efficiency of entire process is as follows:

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$$0.23 \times 0.16 = 0.0368 = 3.7\%$$

The yield of the bioethanol of 290 L/t used here is an ideal value in which almost all cellulose in the woody biomass can be converted into ethanol. The actual yield in practical factory data was reported to be about 40 L/t or less, signifying that the overall efficiency of 3.7% may be much lower.

ii. *Case Ⅱ: thermal power generation using woody biomass → an electrical vehicle (EV)*

Supposing that the efficiency of thermal power using a biomass is 30% and the total efficiency of EV is 80% (containing battery charge, running), the overall energy efficiency would be as follows:

$$0.30 \times 0.80 = 0.24 = 24\ \%$$

Therefore, the overall efficiency in Case Ⅱ is much higher than that in Case 1, even though the assumed ethanol yield is rather optimistic, signifying that automobiles should be driven with electricity rather than an internal combustion engine using bio-ethanol or bio-diesel because the former is highly efficient in energy utilization.

III. "Quantitative" Estimation

In this section, "quantitative" evaluation, or the amount and distribution of readily-utilizable biomass resources and a comparison between the supply and demand, will be discussed.

a) The Amount and Distribution of Biomass Resources

The origin of biomass resources is organic carbon formed by natural photosynthesis, and the amount of fixed carbon is represented by the index of Net Primary Productivity (NPP: called simply "Primary Production"). Although many research reports have been published attempting to estimate the amount and distribution of NPP in various regions and ecosystems, only extremely approximate data is available. So far, the global NPP of 5-35 GT of carbon per year is adopted as the most probable value of a land biomass, whereas the stock biomass is estimated to be about 500 Gt-C. The simple energy equivalent value of this NPP (5-35 Gt C/year) is about ten times larger than the total global energy demands. That was one of the reasons why biomasses have attracted worldwide attention as a candidate for a renewable energy source. In addition, the NPP of a marine biomass is estimated to be 10-40 Gt-C/year, slightly larger than the land biomass, whereas the stock is very small, at about 0.3-1.5 Gt-C, signifying that the turnover rate of marine biomasses is very large. Considering the difficulty of collection and the high moisture content, the marine biomass could not be solely utilized as a fuel resource.

In many cases, the NPP data was computed by multiplying the ecosystem area by a typical unit NPP value of the ecosystem (e.g. forests, grass lands, and savannas), but this unit NPP value often has a very wide range. For example, temperate evergreen forests range from 6-25 tons of dry biomass per hectare per year, savannas from 2-20, and arable lands from 1-35. Also, another difficulty lies in the accurate estimation of an ecosystem area since there are many kinds of vegetation mixed in real ecosystems. Thus, it should be noted that the NPP data always has a potentially large error margin.

There is a large difference between NPP and the amount of available biomasses, which can be estimated as follows:

$$\text{Maximum Potential} = \text{NPP} - (\text{pre-used biomass}) - (\text{waste biomass}) \quad (10)$$

Where, the "pre-used biomass" contains foods and woods (timber and firewood) already consumed. The maximum potential given by equation (10) should be reduced in a stepwise manner as follows:

$$\text{NET-1} = \text{Maximum Potential} - (\text{biomass required to maintain the ecosystem}) \quad (11)$$

$$\text{NET-2} = \text{NET-1} - (\text{biomass difficult to utilize due to geographical and/or economical conditions}) \quad (12)$$

The amount of readily-available biomasses should be estimated using equation (12), but in fact it is rather difficult to evaluate this amount accurately. That is why there is very little data on the readily-available biomass.

b) Energy Equivalent of Forest Biomass

It is obvious that a major part of land biomasses is the forest biomass (wood). Here, the energy equivalent value of forest biomasses currently consumed will be estimated in order to compare it with the primary energy consumption. The common assumption will be that the bulk density of a woody biomass is 0.6t/m^3, and the lower calorific value of woody biomass is 3.4×10^6 kcal/t.

i. *World*

The entire production (or consumption) of wood (as a log conversion) in the year 2007 on a commercial basis was 3591409×10^3 m^3 (firewood 1886182×10^3 m^3, timber wood 1705227×10^3 m^3). The energy equivalent value of this amount, Wb, is as follows:

$$\text{Wb} = (3591409 \times 10^3\ \text{m}^3) \times (0.6\ \text{t/m}^3) \times (3.4 \times 10^6\ \text{kcal/t}) / (10^7\ \text{kcal/t-oil equivalent}) = 0.733 \times 10^9\ \text{kcal/t-oil equivalent}$$

On the other hand, the entire primary energy consumption in the same year, Wt, was 10.583×10^9 kcal/t-oil equivalent. Thus, the ratio for both Wb and Wt equals 0.733/10.583, which equals 0.069, or 6.9%.

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ii. *Japan*

The entire production (or consumption) of wood in the year 2007 was 838799 $\times$ 10^3 m^3 (all timber; domestic 19313 $\times 10^3$ m^3, imported 64565 $\times 10^3$ m^3). The energy equivalent value of this amount, Jb, is as follows:

$$Jb = (838799 \times 10^3\ m^3) \times (0.6\ t/m^3) \times (3.4 \times 10^6\ kcal/t) / (10^7\ kcal/t\text{-oil equivalent}) = 17.1 \times 10^6\ t\text{-oil equivalent}$$

The entire primary energy consumption in the same year, Jt, was 534.9 $\times$ 10^9 t-oil equivalent. Thus, the ratio for both Jb and Jt was 17.1/534.9, which equals 0.032, or 3.2%.

This result shows that the energy equivalent value of an entire currently utilized woody biomass occupies only 3 to 7% of the total primary energy consumption. In addition, over half of the wood utilized in the world is firewood that is already consumed as an energy source. Therefore, biomasses should not be regarded as an alternative energy source for fossil fuel, but be used as local energy on a smaller scale.

IV. Conclusions

The fact remains true that biomasses should be utilized effectively as one of the most valuable renewable resources, because biomasses are the main sources of food, timber, paper and also fuel.

The emphasized points in this article are as follows:

1) In order to quantitatively estimate the contribution of biofuel to the reduction of CO_2 emission, a new index of CO_2 emission reduction as well as its calculation method was proposed.
2) If the purpose is to obtain electricity from solar energy, solar cells are a much better option than power generation by biomass combustion due to the difference in the conversion efficiency.
3) Automobiles should be driven with electricity rather than by an internal combustion engine using bioethanol or bio-diesel because the former is highly efficient in energy utilization.
4) The absolute amount of readily-utilizable biomasses in the energy equivalent value compared with fossil fuel is rather small; only a small fraction of the world's primary energy can be supplied with biomasses, meaning that biomasses should only be used as one of the local energy sources.
5) The priority of biomass use should be as follows according to its economical value: human food should be greater than animal feed, which should be greater than industrial material, which should be great than fuel (energy); thus, the cascade-type biomass utilization system should be sought.

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Relations between Anthropometric Dimensions and Overcome Resistance in Individual Motion

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Summary- The research was carried out on a sample of 124 subjects, 15-16 year old males. An analysis was performed of the relations of anthropometric body characteristics and overcome resistance in individual motion. Obtained information was submitted for mathematical analysis, the MULTREG program, from the statistical program "STAT – PACK" (Gauss – Jordan, 1954, Cooley – Lohnes, 1962). On the basis of maximum cohesion and regressive coefficients, variables that measured body volume, transversal skeletal dimension and longitudinal skeletal dimension have the highest cohesion with the overcome maximum resistance in individual motion from anthropometric body characteristics. The weakest contribution to predicting resistance lies within the variables that measured subcutaneous adipose tissue. High cohesion of variables of the overcome maximum resistance in individual motion with anthropometric body characteristics indicates that a part of the resistance variable in motion is conditioned by mutable flexible anthropometric values. As the overcome maximum resistance in motion is mainly conditioned by the structure for generating intensity and duration of energy release, thus the anthropometric dimensions, especially in the volume segment, body volume and transversal skeletal dimensionality, present a factor that significantly participates in the realization of motion with increased requirements for overcoming maximum resistance in motion.

Keywords: *multiple regressive analysis, relations, anthropometric dimensions, overcome maximum resistance in individual motion.*

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Relations between Anthropometric Dimensions and Overcome Resistance in Individual Motion

Miroslav Dodig

Summary- The research was carried out on a sample of 124 subjects, 15-16 year old males. An analysis was performed of the relations of anthropometric body characteristics and overcome resistance in individual motion. Obtained information was submitted for mathematical analysis, the MULTREG program, from the statistical program "STAT – PACK" (Gauss – Jordan, 1954, Cooley – Lohnes, 1962). On the basis of maximum cohesion and regressive coefficients, variables that measured body volume, transversal skeletal dimension and longitudinal skeletal dimension have the highest cohesion with the overcome maximum resistance in individual motion from anthropometric body characteristics. The weakest contribution to predicting resistance lies within the variables that measured subcutaneous adipose tissue. High cohesion of variables of the overcome maximum resistance in individual motion with anthropometric body characteristics indicates that a part of the resistance variable in motion is conditioned by mutable flexible anthropometric values. As the overcome maximum resistance in motion is mainly conditioned by the structure for generating intensity and duration of energy release, thus the anthropometric dimensions, especially in the volume segment, body volume and transversal skeletal dimensionality, present a factor that significantly participates in the realization of motion with increased requirements for overcoming maximum resistance in motion.

Keywords: multiple regressive analysis, relations, anthropometric dimensions, overcome maximum resistance in individual motion.

I. Problem

Since functional structures of the biological system form an organized and integrated system, and relatively simple relations of resistance in motion and anthropometric dimensions depend on them (4,5,6). This complexity is conditioned firstly with anatomical body structures and physiological mechanisms for motion regulation. Such mechanisms have simple physiological regulatory mechanisms in their structures, which are responsible for the realization of the kinetic structure. There is no doubt, that overcome resistance in motion is a comprehensive part of the musculoskeletal system, and it is thus presumed that certain anthropometric dimensions (the longitudinal, transversal and circular skeletal dimensions and subcutaneous fat factor) have a serious role in the exploitation of resistance in motion (1,2,7,12,13,14). Long limbs, thus long levers, due to their length produce a larger possibility of realizing the amplitude of motion in individual motion. Because of long extremities, the resistance required to overcome motion in space must be described by significantly longer trajectories throughout the process of motion so as to ensure optimal biomechanical functioning of the kinetic chain, than it is the case of the short level system (8, 9, 10). It can be expected that subjects with a larger volume and body bulk, and larger transversal skeletal dimensionality have a bigger impact in motions that are defined with maximum resistance measures. It can be presumed that the positive influence of the volume dimension, body bulk and transversal skeletal dimensionality influence the outcome of motion, where it is necessary to overcome some maximum external resistance, realized in individual motion.

II. Methods

The sample of subjects for this research study amounted to 124 subjects, of male gender ranging from 15 to 16 years of age. The planned sample of 124 Subjects, represents the effect sufficient for any correlation coefficient equal to or larger than .23, consider different from zero with a margin of error lesser than 0.1 or a .99 degree of reliability.

Pursuant to the goal and purpose of the research measuring instruments that have already been validated in the author's prior researches were used (M. Dodig, 2010), and were selected in a manner so as to cover all dimensions of the hypothetical model. Variables for the evaluation of anthropometric characteristics

- Longitudinal skeletal dimensionality; 1.body height (ATV), 2.leg length (ADN), 3.arm length (ADR), 4.biacromial range (ASK).
- Transversal skeletal dimensionality; 1.elbow diameter (ADL), 2.wrist diameter (ADRZ), 3.knee diameter (ADK).
- Body volume and bulk; 1.body weight (AT), 2.mid-range of chest (AOG), 3.upper arm magnitude – extended (AON), 4.upper arm magnitude – bent (AONK), 5.shin magnitude (AOP).]
- Subcutaneous tissue; 1.cutaneous back fold (AKNL), 2.cutaneous stomach fold (AKNT), 3.cutaneous shin fold (AKNP).

Variables for evaluation of resistance in individual motion are defined with overcome maximal

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resistance in realized motion, expressed by the unit of measure for mass – kilogram (kg) 1.lifting with legs from squat (EPDNKG), 2.Pushing with hands from lying position (EPDRKG), 3.arms pulling up from lying position (EPPRKG)

Methods for transformation, condensation and mathematical data analysis are selected according to data analysis requirements. Obtained data are subject to analysis.

Relations of variables which measured resistance in motion and the variable of anthropometric body characteristics are solved with a multiple regression analysis, the MULTREG program, from the statistic program "STAT – PACK" (Gauss – Jordan, 1954, Cooley – Lohnes, 1962). For the purpose of determining relations between predictor variables and criterion variables, the correlation coefficients between each predictor variable and criteria variable (R) were calculated, as were the regressive coefficient of predictor variables (BETA), the standard error of regressive coefficients (SIGMA-D), the T-values of the regressive coefficient of determination of criterion variables (DELTA) and coefficients of regression T (BETA). Furthermore, the coefficients of determination of criteria variables were also calculated, as well as coefficients of multiple correlations between predictor variables and criterion variables (RO) that are derived from a routine evaluation prognosis (SIGMA-D). The analysis of variance tested the hypothesis that the population to which the sample belongs to, the coefficient of determination of criteria variables is equal to zero. For this purpose quadrant sums were calculated, degrees of freedom and middle quadrant, which belong to the linear regression and deviation from the linear regression. In addition, sums of middle quadrants were also calculated for the total variance source. The hypothesis about the nullity of coefficients of determination was tested with an F – test. The percentage of contribution of predictor variables explains the total variances of the criterion variable (P) and (Q) significance of F – test at a reliability level of .99 and .95 along with DF1 and DF2 degrees of freedom, if the real value of the coefficient of determination is zero (Cooley, W. W., Lohnes, P. H., 1971).

III. Results

With analysis of obtained results in the space of variables of anthropometric characteristics in relation to resistance in motion, lifting with legs in individual motion (EPDNKG), table 1, a significant influence is discerned.

Table 1 : Multiple regression of variable (EPDNKG) resistance in motion, lifting legs in individual motion in the system of anthropometric variables

Variables	R	Beta	Sigma-B	T(Beta)
1. AVT	0.12	-0.01	0.02	-0.45
2. AT	0.08	-0.01	0.03	-0.30
3. ADN	0.08	-0.01	0.03	-0.31
4. ADR	0.11	-0.04	0.06	-0.63
5. ASK	0.31	0.22	0.24	0.92
6. ADL	0.20	-0.00	0.17	-0.01
7. ADRZ	0.32	0.04	0.17	0.26
8. ADK	0.39	0.03	0.03	0.99
9. AOG	0.38	-0.00	0.02	-0.12
10. AON	0.45	0.03	0.10	0.32
11. AONK	0.49	0.09	0.08	1.08
12. AOP	0.38	-0.00	0.06	-0.09
13. AKNL	0.19	0.01	0.03	0.53
14. AKNT	0.11	-0.00	0.02	-0.34
15. AKNP	0.06	0.04	0.02	-1.73

DELTA	RO	SIGMA-D	F	P	Q
0.31	0.56	8.42	3.29	21.88%	0.01

Key: ATV – body height, ADN – leg length, ADR – arm length, ASK - bioacromial range, ADL – elbow diameter, ADRZ – wrist diameter, ADK – knee diameter, AT – body weight, AOG – middle range of chest, AON – upper arm range – extended, AONK - upper arm range – bent, AOP – shin range, AKNL - cutaneous back fold, AKNT - - cutaneous stomach fold, AKNP - - cutaneous shin fold.

R – coefficients of correlation between every predictor variable and criterion variable

BETA – regression coefficients of predictor variables

SIGMA-B – standard error of regression coefficients

T (BETA) – values of regression coefficient

DELTA – coefficients of determination of criterion variables

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RO – coefficients of multiple correlations between predictor variables and criterion variables
SIGMA-D – standard evaluation of prognosis
F – test
P – percentage of contribution of predictor variables towards the explanation of the total variance criterion variable
Q – reliability

In the region of predictor variables, the variables that measured the transversal dimensionality of the skeleton have the biggest connection with the criterion (ASK, ADL, ADRZ, ADK) as well as variables that measured body volume (AOG, AON, AONK, AOP). A regressive function ensuring a satisfactory level of multiple regression (0.56) was formed with a linear combination of variables, with a significant coefficient of determination (0.31). The largest contribution towards forming regressive functions have body volume variables (AON, AONK, AOP) and transversal dimensionality variables (ADRZ, ADK, ASK, ADL). Obtained results indicate that for realization of resistance in motion of legs in individual motion, anthropometric characteristics play an important part, manifested as body volume and transversal skeletal dimensionality i.e. larger volume and bone density enable overcoming stronger resistance in motion.

This is also confirmed by the analysis of the variance where the F – test is statistically significant on a level of .99 reliability. Evaluation of the fraction of resistance in motion that can be attributed to multiple regression (the ratio of the average quadrant) in the space of variables with anthropometric characteristics amounts to 78.12%. Their complementary part amounts to 21.88% and evaluates the fraction of variance that is explained by the system of variables of anthropometric body characteristics.

Observing the space of variables of anthropometric body characteristics in relation to resistance in motion, raising arms individual motion (EPDRKG), table 2, a significant impact can be discerned.

Table 2 : Multiple regression of variable (EPDRKG) resistance in motion, raising arms in individual motion within the system of anthropometric variables

Variables		R	Beta	Sigma-B	T (Beta)
16.	AVT	0.16	-0.03	0.01	-1.69
17.	AT	0.17	0.03	0.02	1.82
18.	ADN	0.09	-0.04	0.02	-1.90
19.	ADR	0.18	-0.02	0.04	-0.65
20.	ASK	0.40	0.20	0.15	1.33
21.	ADL	0.35	0.12	0.10	1.17
22.	ADRZ	0.41	-0.01	0.10	-0.10
23.	ADK	0.54	0.01	0.02	0.58
24.	AOG	0.61	0.05	0.01	2.93
25.	AON	0.66	0.05	0.06	0.86
26.	AONK	0.72	0.14	0.05	2.56
27.	AOP	0.50	-0.04	0.03	-1.09
28.	AKNL	0.23	0.00	0.02	0.27
29.	AKNT	0.16	-0.03	0.01	-1.76
30.	AKNP	0.11	-0.02	0.01	-1.75

DELTA	RO	SIGMA-D	F	P	Q
0.67	0.82	5.22	14.77	62.69%	0.01

Key (see Table 1)

In the region of predictor variables, variables that have the strongest connection to the criteria (AONK, AON, AOG, AOP) are the ones that measured body volume. A somewhat lesser connection have those variables (ADK, ASK, ADL, ADRZ) that measured transversal dimensionality of the skeleton. A significantly lesser connection which is borderline significant have variables (AT, ADR, AKNT, AKNL) that measured the longitudinal dimensionality of the skeleton and adipose tissue.

Through linear combination of predictor variables a regressive function was formed which ensures a satisfactory level of multiple correlation (0.82) and a coefficient of determination (0.67). The

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morphological characteristics of transversal dimensionality and body volume gave the biggest contribution to the process of forming the regressive function. Deviation of the predictor from the line of regression ensures enough degrees of freedom which is further confirmed by the regressive prediction, which moves in the range of 5 kg/100. Thus, based on the anthropometric body characteristics it is possible to conduct a prediction of resistance in motion. This is confirmed by the obtained F – test. The evaluation of the variance part that can be ascribed to anthropometric body characteristics based on multiple regression amounts to 62.69% of the total variability, while the smaller part of 37.31% cannot be ascribed to anthropometric body characteristics. A significantly larger fraction of the variance that can be explained through the impact of the system of anthropometric body characteristics, indicates that the larger part of the criterion variance is conditioned by anthropometric characteristics. A distinct significance of variables is noticed in regard to the anthropometric body characteristics in relation to resistance in motion regarding pulling with arms in individual motion (EPPRKG), table 3, what points to a significant impact.

Table 3 : Multiple regression of variable (EPPRKG) resistance in motion, pulling with arms in individual motion within the system of anthropometric variables

VARIABLES		R	BETA	SIGMA-B	T(BETA)
31.	AVT	0.24	-0.01	0.01	-0.53
32.	AT	0.18	-0.02	0.02	-0.92
33.	ADN	0.19	-0.01	0.02	-0.46
34.	ADR	0.23	-0.05	0.04	-1.23
35.	ASK	0.41	0.20	0.15	1.28
36.	ADL	0.27	0.04	0.10	0.43
37.	ADRZ	0.41	-0.02	0.10	-0.21
38.	ADK	0.57	0.05	0.02	2.30
39.	AOG	0.59	0.03	0.01	1.94
40.	AON	0.58	-0.05	0.06	-0.83
41.	AONK	0.63	0.11	0.05	1.96
42.	AOP	0.48	-0.06	0.03	-1.81
43.	AKNL	0.23	-0.01	0.02	-0.74
44.	AKNT	0.20	-0.00	0.01	-0.46
45.	AKNP	0.17	-0.01	0.01	-1.10

DELTA	RO	SIGMA-D	F	P	Q
0.53	0.72	5.33	7.73	45.10	0.01

Key (see Table 1)

In the region of predictor variables the strongest connection with the criterion have those variables (AONK, AOG, AON, AOP, AT) that measure the body volume, variables (ASK, ADL, ADRZ, ADK) that measure the transversal skeleton dimensionality, a somewhat lesser connection those variables (ATV, ADN, ADR) which measure the longitudinal dimensionality of the skeleton and the weakest variables (AKNL, AKNT, AKNP) that measure adipose tissue. a regressive function which ensures a satisfactory level of multiple correlations (0.72) is formed through the linear combination of predictor variables. Variables that measured body volume and transversal dimensionality of the skeleton had the biggest contribution towards forming the regressive function. Deviations in view of the predictor variables from the regressive line ensures adequate degrees of cohesion what is confirmed by the average regressive prediction which moves in the range of 5.33 kg/100.

The obtained results, and to an extent the coefficient of determination of 0.52 is determined on the basis of a system of anthropometric characteristics, thus justifying the evaluation on the grounds that resistance in motion, pulling by arms in individual motion is dependent on anthropometric characteristics. The evaluation of a partial variability also emphasizes this point, and can be ascribed to anthropometric characteristics based on multiple regression (the ratio of an average quadrant of deviation and an original average quandrant) and amounts to 45.10% of the total variability. However, the larger part that amounts to 54.90 % of the total variability cannot be ascribed to multiple regression.

IV. Conclusion

The research was carried out on a sample of 124 subjects, 15-16 year old males. An analysis was performed of the relations of anthropometric body

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characteristics and overcome resistance in individual motion. Obtained information was submitted for mathematical analysis, the MULTREG program, from the statistical program "STAT – PACK" (Gauss – Jordan, 1954, Cooley – Lohnes, 1962). On the basis of maximum cohesion and regressive coefficients, calculated T-values of regressive coefficients between predictor variables and criterion variables, confirmed the significance of the prediction. The Nullity Hypothesis of coefficient determination was tested with the F – test. The percentage of contribution predictor variables explain the total variances of the criterion variable (P) and (Q) the significance of the F – test on a level of reliability of .99 and .95 along with DF1 and DF2 degrees of freedom, confirmed the stated significance. Variables that measured body volume, transversal skeletal dimension and longitudinal skeletal dimension proved to have the highest cohesion with the overcome maximum resistance in individual motion from anthropometric body characteristics. The weakest contribution to predicting resistance lies within the variables that measured subcutaneous adipose tissue. High cohesion of variables of the overcome maximum resistance in individual motion with anthropometric body characteristics indicates that a part of the resistance variable in motion is conditioned by mutable flexible anthropometric values. As the overcome maximum resistance in motion is mainly conditioned by the structure for generating intensity and duration of energy release, thus the anthropometric dimensions, especially in the volume segment, body volume and transversal skeletal dimensionality, present a factor that significantly participates in the realization of motion with increased requirements for overcoming maximum resistance in motion.

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Predictive Values of Motor Dimensions in Motor Space

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Keywords: *factor analysis, motor dimensions, prediction, motor space.*

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Predictive Values of Motor Dimensions in Motor Space

Miroslavdodig

Summary- The research was carried out on a sample of 256 subjects, 15 year old males, obtained from high school student population; a battery of 35 motor tests was used. In the aim of determining the latent structure manifesting motor space the method of main components was applied and thus the factor scores were define Hotelling, H. (1933). For the purpose of determining the relations between the predictive (the motor dimension space) variables and the criteria-based variable (the entire motor space) the coefficient of regression in a latent space was calculated. Through inspection of the results of regressive coefficients it is concluded that the cohesion between systems of predictors and criteria is mainly heterogeneous. The best projections and thus predictive values include: the repetitive strength factor (RF), the velocity factor (VF), the static strength factor (SF), and the explosive strength factor (EF). It is evident that all these factors belong to reactions that are mostly dependent on the process of regulating excitations that represent the existence of the first factor, that is, the general factor of excitation control. Poorer predictive abilities in terms of motor space have the preciseness factor (PF), the flexibility factor (FF), and the coordination (CF), while the balance factor (BaF) is attributed to the weakest predictive ability. Considering the obtained results, a necessity for applying contemporary methods of research within the scope of motor space is displayed. This requires a new, more contemporary way of researching motor space.

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I. Problem

Significant theoretical and practical breakthroughs have been made in structural differentiation and system dispersion in kinesiology in recent years which have influenced its development. The progress of kinesiology depends considerably on the development of new methodological approaches yielding important information. Its purpose is to ensure the transition from single empirically chosen systematically unorganized indicators to systematic model of application. Also, it needs to be said that there are laws of kinesiology that are still to be discovered and stated in an objective qualitative and quantitative form. In spite of numerous scientific attempts made to classify motor space and determine motor space structure, the generalization of date, much has been done in terms of reliable motor measuring instruments construction and systematic have been conducted with respect to factors, and an effort to create a structure model of motor space has been made. This has been made possible due to the contributions made by many researches and scientists: Anohin, K. K. (1970), Bernstein, N. A. (1947), Curetona (1947), Hempel and Fleishmane (1955),Fleishmane (1954), Gredelj, M., Metikoš, D., Hošek, K. &Momirović, K. (1975), Kurelić, N., Momirovič,K, Stojanović, M., Šturm, J., Radojević, Đ. &Viskić-Štalec, N. (1971, 1975), Metikoš, D. & Hošek, K. (1972), Pistotnik, B., Milić, R. (1996), Pišot, R. (1999), Šturm, J., Strel, J. &Ambrožič, F. (1990). Dodig, M. (1979, 2008, 2010), Starosta, W.(2003); and many others. In recent times, a trend of using composite tests which are somewhat more reliable has emerged; however it is still insufficient to encompass a practically limitless variability of motor expression Pišot, R. (1998)., Šturm, J., Strel, J. & Ambrožič, F. (1990). At younger ages. Zhu, W., Cole, L. E.(1996). Magill, R.A. (1997), Bala, G., Popović, B., Stupar, D. (2002). Momirović, K., Wolf, B., Popović, D. (1999). Based on the available research so far, it is extremely difficult to define factor structure and to generalize motor dimensions that exist in motor space in the field of motor science, due to high variability. Despite high variability of motor dimensions structure, motor space has been achieved, but from the structure standpoint it still remains underexplored as well as the factors that determine it. Based on the available analyses, discussions and researches; explosive strength factor, repetitive strength factor, static strength factor as well as velocity, preciseness, flexibility, balance, and coordination factors have been defined. However, regardless of the numerous scientific researches aimed at classifying motor abilities and determining motor dimensions that would define motor space, generalization of results and findings remains impossible. Lack of information is felt in terms of hierarchical structure of motor dimensions and their predictive value with respect to motor space existence. Therefore, the main aim and task of this research is an attempt to explore relations of isolated motor dimensions subsystems and their predictive value in motor system.

II. Methods

a) Sample of Subjects

The sample of subjects was obtained from high school student population, 15 year old males. The sample of subjects consisted of a group of 256 subjects.

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b) Sample of variables

As per research purpose, 35 manifesting kinesiological reactions that have already been information carriers in many previous kinesiological researches have been analyzed on this occasion. Therefore, it was logical to assume that valid predictors of functional structures presented in previous cases would be found in this sample as well.

1. Set of factors of explosive strength (EF) has been estimated with the help of four measuring instruments: 1. MDM – standing long jump, 2. MBMP – medicine ball chest throw, 3. MBML – medicine ball throw laying down, 4. MTRS – standing triple jump.
2. Set of factors of repetitive strength (RF) has been estimated with the help of five measuring instruments: 1. MSK – push-ups, 2. MDTK – lifting up torso from the Swedish bench exercise, 3. MNK – jumps onto the Swedish bench with 1/3 weight, 4. MIST – torso straightening up exercise, 5. MMZ – mixed pull-ups.
3. Set of factors of static strength (SF) has been estimated with the help of five measuring instruments: 1. MIZG – pull-up endurance, 2. MIZ – turn endurance, 3. MIPR – push endurance, 4. MIZP - half-squat with ½ body weight endurance, 5. MIZS – parallel bars endurance.
4. Set of factors of preciseness (PF) has been estimated with the help of four measuring instruments: 1. MPIK – darts, 2. MGAN – hitting a target by foot using a tennis ball, 3. MGAR – hitting a horizontal target by hand, 4. MSTIL – stile.
5. Set of factors of flexibility (FF) has been estimated with the help of four measuring instruments: 1. MISP – a side-turn with a bat, 2. MPS – stretching forward while sitting exercise, 3. MSPA - a split, 4. MPZD – stretch forward – side-turn – touch.
6. Set of factors of velocity (VF) has been estimated with the help of five measuring instruments: tampping by hand, 2. MT4X5 – running 4x5 meters, 3. MTAN – tampping foot against a wall, 4. MD30 – lifting up torso in 30 seconds, 5. MUCL – pressing down while squatting – pressing down while laying.
7. Score of coordination factors (CF) has been estimated with the help of four measuring instruments: 1. MKKII - KKII, 2.MS3M – slalom with three medicine balls, 3. MOZ – agility in the air, 4. M20P – 20 steps forward with a bat.
8. Score of balance factors (BaF) has been estimated with the help of four measuring instruments: 1. MRAV – standing on one leg with eyes closed, 2.MPSG – standing diagonally on a low beam 3. MSOK – standing on an upside-down balance bench, 4. MSUK – standing horizontally on one leg on a balance bench.

For hypothetically defining the entire motor abilities space, motor dimensions were considered, those which had been extracted during the preliminary research: (1) explosive strength factor (EF), (2) repetitive strength factor (RF), (3) static strength factor (SF), (4) preciseness factor (PF), (5) flexibility factor (FF), (6) velocity factor (VF), (7) coordination factor (CF), (8) balance factor (BaF).

c) Methods of data analysis

Methods of data transformation, condensation, and mathematical analysis have been chosen according to the data analysis demands. By using standard descriptive procedures, characteristics of the measuring instruments have been determined. Arithmetic means (XA), variances (SIG2), standard deviations and half-range in which there is a 95% fluctuation in the real value of arithmetic mean (DX). Minimum (MIN) and maximum (MAX) result values have also been determined, and all results have been categorized in corresponding classes. Normality of Distribution Hypothesis has been tested using the Kolmogorov-Smirnov test, which allows for the rejection of a hypothesis if a maximum difference allowed (MAXD) between obtained relative cumulative frequencies (FCR) and expected relative frequencies (FCT) is bigger than, or equal to, the value given under the TEST mark. The coefficients of correlation (R) of all manifesting variables as a product of set vectors of standardized results have been calculated. Seeing as a preset value for zero-hypothesis rejection is an error set at 0, 05 all coefficients bigger than .12 can be considered statistically significant. Specific variances of manifesting variables from inverted correlation matrix have been calculated (specific variance contains error variances and specific variables variance).Partial correlations (RP) of manifesting variables have also been calculated, i.e. coefficients of interconnectedness of manifesting variables pairs (the mentioned data has not been presented due to its extensive volume).

Furthermore, factor analysis of motor space with manifesting variables has been made relative to motor dimensions scores. With the aim of determining latent structure of manifesting variables of motor subspaces, the inter correlation matrix has been factorized using Hoteling's Principal Components Method and in this way factor scores have been defined, Hotelling, H. (1933). Based on the obtained factor scores, partial correlations (RP) within factor scores have been calculated, i.e. the coefficients of interconnectedness of factor scores pairs. Characteristic inter correlations matrix square roots have been marked with LAMBDA. A criterion according to which first principal component whose characteristic first and largest square root is always bigger than 1.0, is considered significant; has also been determined. Both

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the characteristic square root and the relative cumulative contribution that explains the overall variables variance have been calculated. The value of relative cumulative contribution of the largest square root multiplied by 100 gives the explained variance percentage for the entire system of manifesting variables. The main components of the inter correlations matrix are shown under (H). Furthermore, communalities (h2) of the predictive variables have also been calculated. It is a part of variance of every predictive variable that can be explained in terms of an isolated latent dimension system. With the aim of determining relations between predictive (motor dimensions subspace) variables and criterion variable (the entire motor space) the coefficient of regression (B) in latent space has been calculated.

III. Results

As per research purpose, 35 manifesting kinesiological reactions that have already been information carriers in many previous kinesiological researches, as well as a number of new or modified measuring instruments, have been analyzed on this occasion. Therefore, it was logical to assume that valid predictors of functional structures presented in previous cases would be found in this sample as well.

According to the obtained results, it can be concluded that the parameters and distribution of subspace scores of motor variables are normal based on the test criteria proposed by Smirnov and Kolmogorosov. Based on the data obtained, inter correlations, partial correlations and specific score variances of all subspaces of motor space have been calculated. By inspecting inter correlation scores matrix of all subspaces (Table 1 above the large diagonal) applied for determining the entire motor space, first and foremost, the information about the level of cohesion of motor space dimensions was obtained.

Table 1 : Intercorrelations (above the large diagonal). Partial c orrelations (below the large diagonal) and specific variances (in the large diagonal) of motor factors

	EF	RF	SF	PF	FF	VF	CF	BaF
EF	.68	.49	.28	.21	.29	.43	-.24	.13
RF	.32	.47	.60	.29	.20	.54	-.28	.25
SF	-.07	.45	.58	.38	.16	.44	-.18	.15
PF	.05	-.01	.26	.80	.08	.28	-.25	.08
FF	.16	-.07	.02	-.07	.80	.35	-.28	.17
VF	.17	.26	.14	.10	.24	.60	-.22	.20
CF	-.06	-.11	.03	-.18	-.20	.01	.18	-.24
BaF	-.04	.13	-.01	-.02	.07	.06	-.16	.89

Legend: (EF) Explosive strength factor,(RF) Repetitive strength factor, (SF) Static strength factor,(PF) Preciseness factor,(FF) Flexibility factor, (VF) Velocity factor, (CF) Coordination factor, (BaF) Balance factor.

Values of correlation coefficients between motor dimensions range from .08 to .60 meaning there is a wide range of cohesion within the entire motor system, which consequently results in instability within certain dimensions of the system. Explosive strength factor (EF) has the strongest correlation coefficient with the repetitive strength factor (RF) .49, and with the velocity factor (VF) .42. Relatively strong factor correlations between the explosive strength factor and these two factors were to be expected due to the mechanism on which the factor in question is based, which is the regulation of excitation intensity.

Repetitive strength factor (RF) and velocity factor (VF) in their respective structures contain activation of a large number of motor units in order to develop force, which is needed as the starting impulse to perform movement. Explosive strength factor is dependent on a basic structure, basic mechanism; i.e. that factor is primarily dependent on one regulative mechanism whose task is to decode excitation intensity in primary centers and in factors. Explosive strength factor has weak but significant correlations with other factor which was to be expected considering the regulation of movement mechanism. Its weakest correlation is with the balance factor which is understandable.

Repetitive strength factor (RF) which is characterized by intensity regulation and duration mechanism. Logically, it has the strongest coefficients of correlation with those factors that have similar mechanism structure. It shares its strongest correlations within the motor system with the static strength factor (SF) .60 which also represents the strongest correlation in the entire system. It also has good correlations with the velocity factor (VF) .54 and the explosive strength factor (EF) .49. It is clear that mechanisms for intensity regulation and duration are responsible for such coefficients of correlation. Repetitive strength factor has significant coefficients of correlation with all other factors, the weakest of which is with the flexibility factor (FF) .20. It should be pointed out that the repetitive strength factor has the strongest correlation in the entire space with respect to other factors.

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Static strength factor (SF), whose variability and covariability are dependent on the intensity regulation and duration mechanism; has the strongest coefficient of correlation with the repetitive strength factor (RF) .60, which was to be expected. Also it has a relatively good correlation with the velocity factor (VF) .44 and the preciseness factor (PF) .39. With other factors it has weaker coefficients of correlation; however, all are significant; it has the weakest correlation with the balance factor (BaF) .15. The interconnection of static strength factor (SF) and the repetitive strength factor (RF) is logical seeing as it includes a transfer of regulation mechanism for the said structures. Based on the obtained correlations between the static strength factor and factors of velocity (VF) and preciseness (PF), here can be assumed the existence of relation between the process of excitation intensity and duration and the process of referentation control contained in the latent structure of velocity and preciseness factors. Such assumption confirms the fact that it is a process of primary referentation which is the characteristic of balance factor (BaF) where the correlation is weak, but that it is a secondary referentation.

Preciseness factor (PF) whose variability and covariability are dependent on the mechanism for bilateral integration of movement, formation of ideomotor structures and control of referentation process. The preciseness factor has the strongest interconnection with the static strength factor (SF) .38, repetitive strength factor (RF) .29 and the velocity factor (VF) .28. It has somewhat weaker, but still significant correlations with the explosive strength factor (EF) and coordination factor (CF), while it has very weak and insignificant correlations with the flexibility factor (FF) and the balance factor (BaF), which are also the only insignificant coefficients of correlation in the entire system of motor factors.

Flexibility factor (FF) whose variability and covariability are dependent on the mechanism for regulation of synergic processes, referentation process, regulation of tonus of muscle groups and relaxation of antagonists. The flexibility factor has the strongest correlations with the velocity factor (VF) .35, explosive strength factor (EF) .29 and coordination factor (CF) .28. It has slightly weaker but significant correlations with the repetitive strength factor, coordination factor and static strength factor; while it has insignificant correlation with the preciseness factor.

Velocity factor (VF) whose variability and covariability are dependent on the mechanism for bilateral integration of movement, formation of ideomotor structures and control of referentation process, and alternative innervation of muscles. It has the strongest correlations with the repetitive strength factor (RF) which is logical because repetitive strength factor contains a fair amount of alternative innervation of muscles, and that particular mechanism is one of the principal regulators in the velocity factor system. Furthermore, this factor also has relatively good correlations with the static strength factor (SF) .44 and the explosive strength factor (EF); it is probably the case of same transfer relations from the same mechanism. Also, it has relatively good correlation with the flexibility factor (FF), which is probably the result of the influence of the process of tonus regulation and muscle relaxation of agonists and antagonists, which is a part the mechanism structure for regulation of flexibility. As far as other factors are concerned, the velocity factor has slightly weaker but nevertheless significant correlations. He is factor that has second strongest correlations overall, as far as the entire space of motor factor is concerned.

Coordination factor (CF) whose variability and covariability are dependent on the mechanism for bilateral integration of movement, formation of ideomotor structures and referentation control. The coordination factor has all significant coefficients of correlation (the negation in front is the consequence of measuring instruments structure that attribute stronger value to weaker result thus changing it), and it has the strongest correlation with the repetitive strength factor (RF) . 28, the flexibility factor (FF) .28, and a slightly weaker with the explosive strength factor, the preciseness factor and the balance factor. It has the weakest correlation with the static strength factor .18.

Balance factor (BaF) whose variability and covariability are dependent on the mechanism for bilateral integration of movement, formation of ideomotor structures and control of referentation process. The balance factor is the factor with the weakest coefficients of correlation with other factors in this entire space, which was expected due to the structure of measuring instruments and their projections for the joint measuring object. It shares the most significant correlations with the repetitive strength factor .25 and the coordination factor .24, while other correlations are weaker but significant, except for the preciseness factor which is insignificant.

Partial correlations (Table 1 below the large diagonal) show cohesion between factors with the remaining system of factors orthogonalized, making it a constant unable to influence the cohesion between factors. Partial correlations in the entire motor space are different from the original in that they are weaker, and some also have negative partial connection, which is not true for the correlation factor whose negativity stems from the structure of measuring instruments. When the influence of other factors is isolated then the repetitive strength factor (RF) and the static strength factor (SF) have the strongest particle correlations in the entire space. The repetitive strength factor and the preciseness factor have the weakest partial correlation that is also negative. The balance factor has negative partial correlations with the explosive strength factor, the

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preciseness factor, the coordination factor, and the static strength factor. It is clear that the balance factor does not have a lot of points in common in this space. Specific variances of factors in the entire motor space (Table 1, in the large diagonal) are indicative of the highest possible percentage of variance error contained by a specific factor in its measuring structure. Those values are proportionally high particularly in those latent dimensions that have the mechanism of regulation responsible for the bilateral integration of movement, and especially for the formation of ideomotor structures and the control of referentation process. Those factors that have regulation mechanisms based on the simple structures of excitation intensity and duration have fairly solid specific variances. The coefficient of determination is fairly low which means that the lowest possible variance that is valid in the entire system is 29, 28%. The reason for high specific variances and low coefficient of determination lies primarily in inadequate measuring instruments used to deal with the motor dimensions of preciseness, coordination, balance and flexibility. By solving characteristic equations and calculating characteristic Lambda square roots in the entire motor dimensions space (Table 2) the main scores component of all motor space subspaces was obtained.

Table 2 : Significant characteristic matrix square roots of factor intercorrelations and cumulative proportion of the explained variance

	LAMBD	CUMULATIVE	
1.	3.04	.38	the last own value used
2.	1.10	.52	
3.	.72	.63	
4.	.85	.74	
5.	.68	.82	
6.	.60	.90	
7.	.49	.96	
8.	.32	1.00	

Legend LAMBDA – characteristic square roots of matrix intercorrelations, CUMULATIVE- relative cumulative square root contribution.

It is evident that the isolated main component of the set has accounted for 38% variance of the entire motor system, which also represents the main information carrier about this system. Hotelling factor matrix – (Table 3) shows orthogonal projection of the variables to the isolated main component. The results show that the strongest projections to the main component in the entire motor system belong to the repetitive strength factor (RF), the velocity factor (VF), the static strength factor (SF) and the explosive strength factor (EF). Weaker projections belong to the coordination factor and the preciseness factor, while the balance factor has the weakest projection.

Table 3 : Main component of the factorintercorrelations matrix (H), communalities (h2) and coefficients of regression (B)

	H	h2	B
EF	.66	.43	.22
RF	.80	.65	.26
SF	.70	.49	.23
PF	.52	.27	.17
FF	.48	.23	.16
VF	.75	.56	.25
CF	-.51	.26	-.17
BaF	.39	.15	.13

Legend (see Table 1)

H – Main components of intercorrelations matrix, h2 – communalities, B – coefficient of regression

Communalities (Table 3-h2) are relatively good for the repetitive strength factor (RF), the velocity factor (VF), the static strength factor (SF), and the explosive strength factor (EF); which leads to the conclusion that the said factors are responsible for the biggest contribution in terms of the isolation of the main component. Lower communalities, some of which are borderline acceptable, include the preciseness factor (PF), the coordination factor (CF), and to an extent, the flexibility factor (FF). The lowest and extremely weak communality has the balance factor (BaF).

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Regression coefficients of the scores of all motor space subspaces (Table 3-B) show cohesion between motor dimensions and the entire motor space and are generated in the main component section. In this way, predictive values of specific dimensions in motor space are obtained. By inspecting results of the regression coefficients, it can be concluded that the cohesion between the system of predictors and the criteria is rather heterogeneous. Segments of factor projections to motor space range from .13 to .26. The best projections and thus also the best predictive values belong to: the repetitive strength factor (RF), the velocity factor (VF), the static strength factor (SF) and the explosive strength factor (EF). It is evident that all these factors belong to reactions that are mainly dependent on the process of excitation regulation which represents the existence of the first line factors, i.e. the general factor of excitation control. The preciseness factor (PF), the flexibility factor (FF), and the coordination factor (CF) have poorer predictive abilities in terms of motor space, whereas the balance factor (BaF) has the poorest predictive ability. All these factors belong to a group of reactions that is dependent on the process of regulation of integration, regulation and control in the second line space. Poor predictive value of factor that are regulated by the general factor of integration, regulation and control, is based in the inadequate structure of measuring instruments that have poor liability. Regardless of the numerous studies conducted about the latent motor space structure, the said space has yet to be determined. Based on the available analyses, discussions and researches motor space has been partially defined, however, it is still insufficient, seeing as the available results are neither cohesive nor conclusive enough. Considering the quantitative and qualitative versatility of movement in certain body segments, or in body as a whole; it is more or less possible to achieve large movement variability. Based on anatomic, functional, and biomechanical laws, which represent the source of a partial explanation for the body movement phenomenon; formation of a whole range of codependent movement factors is possible. In order to achieve movement, integration of a wide spectrum of factors must be achieved, with both bone and joint elements, and muscular and nerve structures having the primary role. There are no independent local processes; which means that every element has its own specific importance in the movement process. The main reason lies in the exclusive use of phenomenologically determined group of individual motor expression. Furthermore, the use of different methods, samples that are too small, inadequate data-checking; and above all, lack of adequate measuring instruments; contributes to such a situation. Due to all this, there is not enough information about correlations between motor dimensions within motor space; which consequently leads to the necessity of developing a different, more contemporary and more efficient research approach in kinesiology.

IV. Conclusion

The research was carried out on a sample of 256 subjects, 15 year old males, obtained from high school student population; a battery of 35 motor tests was used in the aim of analyzing motor space and conducting predictive value of factor scores on motor space. The main problem that needed to be solved was a problem of objective defining of latent motor dimensions, and the main task was determining the existence and nature of manifesting variables in latent space of motor dimensions and their predictive value in motor space. By performing standard descriptive procedures, the characteristics measuring instruments were determined. Furthermore, factor analysis of motor space relative to motor dimensions scores was conducted with the variables. In the aim of determining the latent structure of manifesting motor space variables the intercorrelation matrix has been factorized using Hoteling's Principal Components Method and in this way factor scores have been defined, Hotelling, H. (1933). For the purpose of determining the relations between the predictive variables and the criteria-based variable the coefficient of regression in a latent space was calculated.

The obtained predictive values of specific dimensions in motor space between the system of predictors and the criteria are rather heterogeneous. Segments of factor projections to the motor space range from .13 to .26. The best projections and thus also the best predictive values belong to: the repetitive strength factor (RF), the velocity factor (VF), the static strength factor (SF) and the explosive strength factor (EF). It is evident that all these factors belong to reactions that are mainly dependent on the process of excitation regulation which represents the existence of the first line factors, i.e. the general factor of excitation control. The preciseness factor (PF), the flexibility factor (FF), and the coordination factor (CF) have poorer predictive abilities in terms of motor space, whereas the balance factor (BaF) has the poorest predictive ability. All these factors belong to a group of reactions that is dependent on the process of regulation of integration, regulation and control in the second line space. It is known that motor abilities participate in performing motor tasks and represent manifesting motor space. Seeing as the number of expressing motor tasks is limitless, in analyses, Pzhenomenologically determined groups of individual motor expressions are exclusively used. This demonstrates there are numerous measures that define that space. Parameters that are used for measuring motor abilities of strength, velocity, coordination, flexibility, preciseness, and balance are based on the phenomenological characteristics of the said space. Phenomenological characteristics of motor

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space are determined by factors that gain their importance according to the abilities that share the biggest part of their variance with the factor. It is, therefore, the structural approach that enabled factor determination from explosive strength, repetitive strength, static strength and velocity segments; which was not the case with coordination, flexibility, preciseness and balance motor space. Poor predictive value of factors that are regulated by the general factor of integration, regulation, and control of movement processes; lies in the inadequate structure of measuring instruments with poor liability. Consequently, a necessity for applying more contemporary methods of research in order to discover the truth about motor space is displayed. This requires a new, more contemporary way of researching motor space.

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A Review of Bird Control Methods at Airports

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Abstract- Birds are a serious problem at airports threat to aviation safety. Since the early days of aviation, collisions of aircraft and birds have taken place, sometimes with fatal consequences. Generally, the damage due to their size of the bird species involved, hunting behavior, and hovering/soaring habits. The combination of abundant food sources, open space, and availability of perching structures on airport grounds and near runway/taxiway areas provides ideal hunting opportunities for many raptors. Also, the behavior of bird species influences the risks, for instance flocking or certain migration patterns and flying altitudes. Development of larger, faster and quieter aircraft, jet engines and intensification of air traffic caused an increase in the number of incidents. Military exercises involve flying at high speed an low altitude, and are exposed to a more serious risk.

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A Review of Bird Control Methods at Airports

Abd El-Aleem Saad Soliman Desoky

Abstract- Birds are a serious problem at airports threat to aviation safety. Since the early days of aviation, collisions of aircraft and birds have taken place, sometimes with fatal consequences. Generally, the damage due to their size of the bird species involved, hunting behavior, and hovering/soaring habits. The combination of abundant food sources, open space, and availability of perching structures on airport grounds and near runway/taxiway areas provides ideal hunting opportunities for many raptors. Also, the behavior of bird species influences the risks, for instance flocking or certain migration patterns and flying altitudes. Development of larger, faster and quieter aircraft, jet engines and intensification of air traffic caused an increase in the number of incidents. Military exercises involve flying at high speed an low altitude, and are exposed to a more serious risk.

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I. Introduction

During the 1966 Bird Control, we began to look at birds as a hazard to aircraft, and a possible new role was emerging for the pest control industry. Ten years later, we have yet to see the concept of bird control as seen through the eyes of our Canadian and European counterparts. You know of the assistance role the Air Force is playing in reducing bird strikes, and the Federal Aviation Administration is beginning to actively participate in bird control programs.

Raptors are often attracted to airports by the presence of birds, rodents, or other small mammals that are accommodated by the stands of poorly-maintained grass and border, or edge, habitats present. [Desoky, 2014; Baker and Brooks, 1981] found raptors to be highly dependent on voles for food at Toronto International Airport .Success has been seen in habitat modification as a means of reducing bird strikes. The Canadians [Blokpoel, 1976] have reduced damaging bird strikes significantly. Air Canada's average yearly cost for damage in 1959-63 was $173,000. From 1969-73, just ten years later,

Raptors, including hawks, vultures, and eagles, were the fourth most common bird group reported in bird strikes to the FAA from 1990 -1998 (Cleary *et al.* 1999), and hawks, more specifically, were the fifth most common bird group reported in bird strikes in Canada from 1991 -1997 (Transport Canada 1998). Red-tailed hawks were the sixth most common bird species reported in U.S. Air Force bird strikes from 1985-2001, resulting in over $13 million in damage costs (Transport Canada, 1994 and USAF 2001).

This case was reduced to an average of $86,000 per year. This is remarkable when you consider the increases in flight operations, repair costs, and inflation over the ten-year period. Modification of the airfield environment is possible, and the Air Force is doing it routinely at many bases. A more complex problem is land use, which attracts birds beyond the airfield boundary .An airport authority or military base has little or no control over matters outside its territory. Usually it is extremely difficult to implement recommendations to reduce known bird hazards. Progress is slow in altering community land because of a wide variety of organizational, legal, financial, or political reasons. Certain land use practices must be examined in preparing comprehensive plans and bird control programs. Scientists and technicians working with birds have the necessary knowledge to identify problems with land use which will aid in planning for the future. To appreciate the problems created by land use, we must examine a few uses found near airports [Davidson *et al.*, 1971].

Air traffic in South Africa is increasing and it is essential to ensure that international air safety standards are maintained at South African airports. Little has been done in the past to co-ordinate the management of bird related safety risks at South African airports. In order to improve the situation, the Airports Company South Africa (ACSA) has entered into a unique strategic partnership with the Endangered Wildlife Trust (EWT), a nongovernmental organisation committed to the conservation of southern Africa's biodiversity, to establish and operate an integrated national bird control program. The aim of the project is to minimise bird strikes and other interactions between wildlife and airport facilities at ACSA airports by applying environmentally-sensitive management techniques. [Froneman, 2000].

Airport staff is involved in the monitoring of bird strikes and bird populations on or near airports in order to gain a better understanding of population dynamics. Emphasis is placed on proactive bird control measures involving ecological solutions such as habitat management. However, during the establishment phase of habitat alterations, more re-active bird control measures are used to scare birds away from high-risk areas on the airfield. During its first year of operation the project has made significant progress. One hundred and forty eight bird strikes were reported from 13

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airports across the country. The data recorded have helped to narrow the problem down to specific species and to prioritise actions through analysing bird strike rates for the different airports. In addition to refining the reporting system the project currently focuses on establishing appropriate environmentally sensitive bird control measures [Anderson and Kok, 1991].

Wildlife control committees have been established at ACSA airports and they form the basis of an improved bird strike reporting and bird control monitoring programme. The formation of a South African Airport Wildlife Working Group under the auspices of the partnership is envisaged to share information from a national and international level with all stakeholders.

The study comprised gathering and analysis of international literature and publications on bird control, in order to obtain an overview of bird control at airports.

II. Habitat Modification

All birds need food, cover (including shelter, safety, places to nest, rest and roost) and water to survive. Design and management of the airport habitat in such a way that these elements are eliminated or minimised (aimed at the locally most hazardous species), will reduce the local population of birds [Blokpoel, 1976, and Project Mainport en Milieu, 1993]. Habitat modification should be aimed at the problem species. Because habitat modification will not only affect the target birds, but also other bird species and animals, it is not highly selective. It is also important not to create circumstances that are attractive to other species. Habitat modification is considered to be a very effective and enduring way of preventing the presence of birds. Measures should be based on ecological research of the airport area and its surroundings; every airport offers a unique situation. Continued and properly specialised maintenance of vegetation and water is an important condition to success [Desoky, 2014 and Godsey, 1997].

III. Model Aircraft

Remote-controlled model aircraft, shaped in the silhouette of a bird of prey, have been tested with success (on gulls in the Netherlands, on Dunlin in Canada). The small aircraft are flown across or towards the target birds by remote control, in such a way that a raptor is imitated. Tests in France showed that shape, colour and noise of the model did not influence results, but that the way the model was piloted was most important [Stenman, 1990]. Maneuvering the aircraft is said to be difficult, especially in windy circumstances and in busy aviation traffic. There is no information on habituation [Grote, 1994 and Burney, 1999].

IV. People Vehicle

Slow arm weaving has been tried successfully on gulls, perhaps because the movement imitates the flight of a large raptor (e.g. White-tailed Eagle) [Kuyk, 1981]. There will be many variations on this theme, such as imitation wings fixed on a vehicle etc. However, little information was found in literature. The mere presence of people or the bird patrol vehicle is enough to scare away some species. Persons holding shotguns (or even models) are successful, especial ly where hunting is common practice. In some cases it is noted that habituation to this way of visual scaring is much less than to other dispersal techniques [Stenman,1990].

V. Mylar-Tape

In agriculture, mylar tape is used as a 'scarecrow' to keep birds out of crops. Twisted strands tied to sticks move in the wind and flash in the sun, and they appear to have a frightening effect. Fences of Mylar tape are also used in agriculture. Although the use of Mylar-tape is mentioned in relation to bird control, no examples of use at airports were found [Cleary, 1998].

VI. Eye Spots

With eye spots on flags, balloons or doors no positive results are obtained. There may be an initial reaction, but birds get used to them very quickly .Eye spots on aircraft (e.g. engine spinner) are studied with various outcome: negative [Godsey, 1997] to a 20% reduction of bird strike [Stenman, 1990].

VII. Lights

Various types of light source (search, rotating, flashing, laser or strobe lights) are tried and/or used, sometimes in combination with mirror systems [Godsey, 1997]. Flashing ('anti -collision') lights are commonly used on aircraft; birds are better able to detect an approaching plane and avoid it. Flashing lights are also used on bird patrol vehicles. The flashing frequency should be less than 100/sec. Search lights have shown to have some effect in darkness. A strong light beam can scare gulls at a distance up to 800 m. Tests have indicated that blue light may be more effective than other colours, perhaps due to a higher sensitivity of the bird's visual senses to 'blue' wavelengths. Fixed strobe lights have been successful inside buildings, but they are not practical outside. Laser is considered not very successful, although there have been good results with a portable helium -neon laser in France [Kuyk, 1981and Stenman, 1990]. However, test results also showed that the required laser intensity would be dangerous to animals and man [Blokpoel, 1976]. It has been concluded that the approach-lights alongside landing-strips reduce bird strike (during day light) by 50%.

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Probably, they improve a bird's timely detection of an approaching plane [Thorpe, 1996]. Care should be taken with the use of lights, because migrating passerines are known to be attracted by lights at night. Especially during falls, increased numbers of passerines have been recorded at or around lighthouses, lightships or illuminated large industrial areas along the coast.

VIII. Resource Protection

Resource protection comprises all activities that make areas inaccessible or less attractive to birds. Apart from food, cover and water, airports often offer relative 'quiet' conditions, because there is little disturbance apart from engine noise. This is attractive to birds and can be an important factor in their presence [Project Mainport en Milieu, 1993 and World Top 50 Airports, 1998]. Resource protection measures include 'passive' (e.g. wires across ponds, spikes on ledges) and 'active' (harassment with chemical, audio or visual means) methods, hereafter called exclusion and repellents respectively [National Wildlife Research Centre, 1999]. The success of active harassment depends not only on the methods and bird species, but also on the shape the target birds are in. When breeding, tired or hungry, gulls for example are harder to chase away. Also, the availability of alternative sites for birds in the vicinity determines the success [MacKinnon, 1996]. This may be especially important in case of an island in sea. Due to the adaptive abilities of birds, habituation to repellent techniques is a serious problem in bird control [Bird Strike Committee Canada and Bird Strike Committee USA, 1999; Godsey, 1997 and Kuyk, 1981.], Similar methods used at different airports may yield completely different or even contradictory results. Therefore, it is nearly impossible to judge effectiveness of most visual and audio repellents from experiences. At many airports, the effectiveness of repellents is assessed by testing in the field [MacKinnon, 1997].

IX. Exclusion

Access to attractive areas can be denied or discouraged by using physical barriers. Such barriers are mainly used for buildings and for open water, but also for landfills. Buildings are used by birds as roosting (or even breeding) sites, for example Starling and pigeons on ledges or in hangers, gulls on open water or on rooftops. Favoured areas, such as ledges, setbacks and flat surfaces can be closed off with netting, screening, spikes, wires or sticky substances (the latter only having a temporary effect). On flat ledges, metal strips can be applied with an angle greater than 45o. Using curtains of heavy plastic sheets will prevent the use of openings or doorways; making a ceiling with nets or cloth will prevent birds to roost under roofs or shelters [Blokpoel, 1976 and Cleary, 1998]. Water bodies such as ponds or lakes can be made inaccessible with wire systems. The grid of the wire system depends on the target species. For gulls, a grid of 6 x 6 meters proved to be useful, for waterfowl a smaller grid (3 x 3 meters) is needed. Exclusion of water is also possible with nets [Cleary and Dolbeer, 2000]. Exclusion of landfills as a food source (mainly important for gulls) is best done by daily covering of the waste. Wire systems have also been successfully used on landfills. Waste sites at meat- or fish-processing industries should also be carefully covered. Gulls appear to use several feeding sites spread out over a large area. It is therefore important to take measures at all potential feeding grounds in wider surroundings than just the close vicinity. Large, horizontal nets have been described by [Kuyk, 1981] as a means of keeping birds away from airport fields. However, such nets make maintenance of the terrain difficult. Experiments have been conducted with heated surfaces, based on the assumption that gulls prefer warm surfaces for roosting or loafing. No positive results were obtained [Blokpoel, 1976].

X. Audio Repellents

Birds can (temporarily) be chased away with sounds by using pyrotechnics, propane gas cannons or bioacoustics. In general, loud noise itself does not seem to bother birds [Blokpoel, 1976]. Experience with and a result of audio repellents varies greatly between countries [Stenman, 1990].

a) Pyrotechnics

Pyrotechnics are noise producing devices such as scare cartridges, shell crackers, fireworks, alarm pistols, shotguns and electronic alarms (the latter being little used). They are often effective, easy and safe to use and are thus widely used, nearly always in combination with bioacoustics, visual scaring or shooting. Additional development of smoke is occasionally used. Flares are not widely used but tend to have a good effect [Blokpoel, 1976; Klaver, 1999 and Stenman, 1990]. Apart from the audio effect of the explosion, there is also a visual effect of light and smoke. Flares are normally fired from a Very pistol. At Schiphol, the Very flares have been replaced by shell crackers that do not leave debris (dangerous on runways). The effect of shell crackers varies, due to habituation. Birds can be dispersed in a desired direction by carefully locating the sound source or firing in a certain direction (cartridges) [Cleary and Godsey, 1997]. Sirens on vehicles are used with some success. Automatic noise generators along runways are used successfully on Lapwing, gulls and pigeons [Jonkers and Spaans, 1997].

b) Gas cannons

Propane, carbid or acethylene gas cannons are less widely used, probably because habituation can occur comparatively quickly. They can be very effective

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on gulls, waterfowl and other game birds (the latter being hunted and associating the noise with danger), especially when used when (migrating) birds come in to feed or roost. Frequent relocation, varying the frequency of detonations and combination with other harassment techniques will prevent habituation and improve the effect [Blokpoel, 1976 and Godsey, 1997].

c) Bioacoustics

Bioacoustics work through broadcasting of pre-recorded bird distress calls. These calls are specific to a bird species, although Godsey mentions that non-specific distress calls are the most effective [Godsey, 1997]. Experiments with synthesised versions of calls have been successful as well. The birds will interpret the calls as an alarm signal and fly away, perhaps enhanced by group behaviour. However, other responses, such as flying towards the source to check out the 'danger', have been reported, creating a potential momentary hazard (gulls, Corvids. Distress tapes are (preferably) played from a sound system on a vehicle, producing 90 to 100 decibel. Fixed systems have proved to become ineffective in time in several countries. After the birds have been identified and the tape is selected, the birds are approached to a minimum of 100 to 200 meters (depending on the local situation) and the call is played for a short interval (15 to 20 seconds, to prevent habituation). In the Netherlands, an automatic randomising system is used to broadcast distress calls. Gulls, starlings and crows can be dispersed with distress calls. Not all species react to bioacoustics (Lapwing, Oystercatcher and Starling appear to be difficult); several calls may be tried. The response may also depend on the birds' behaviour or state (hungry, tired or breeding birds showing less response) [Blokpoel, 1976]. In practice, bioacoustics are very often used in combination with other measures to prevent habituation. Combinations with pyrotechnics, hunting or incidental killing provide good results in many countries [Stenman, 1990]. In Britain, the main problem species react to their distress calls. Before using distress calls, investigations are needed into the problem species, their calls, the circumstances in which the calls should be used, the required quality and equipment and the best way of reinforcement.

d) Ultra-sound, infra-sound, radar

These sound sources are generally regarded as not effective in scaring birds. Tests at various locations and under various circumstances have, in some cases, provided contradictory results. However, there is no hard proof for any positive effect .Generally, ultra-sound (using very high frequencies) has appeared to be unsuccessful in chasing away birds [Blokpoel, 1976 and Godsey, 1997]. The hearing range of birds is assumed to be narrower than the human range (proven for Pigeon, House Sparrow and Starling), so sounds inaudible to humans are inaudible to birds [Cleary and. Dolbeer, 2000]. Moreover, ultrasound requires much power and quickly loses strength with distance. Contrastingly, one record of successful use of ultrasound was found in literature: at Venice airport in Italy ultra-sonic equipment has reportedly been used with success on gulls.

The experimental circumstances in which these results were obtained are not mentioned [Stenman, 1990]. According to some sources, birds species may be sensitive to infra-sound (low frequency) and use it for navigation. The same may be true for modulated radar, as several observations indicate. According to other sources, however, radar does not seem useful for scaring birds [Kuyk, 1981]. Studies are underway to test this possibility [Cleary, 1998]. The noise of aircraft engines is being studied to determine if certain frequencies are suitable for scaring birds. There may be overlap in frequencies between engine noise and distress calls. Studies to investigate these subjects are currently underway [MacKinnon, 1996].

XI. Visual Repellents

a) Carcasses or models of dead birds

This method of agricultural origin is widely practised, with varying results. Dead birds 'wear out' quickly; their use can be extended by conservation with formaldehyde. Plastic models (dummies) or mounted specimens are more durable, but the effect seems to less compared to carcasses. Incidentally, problems with animals or birds of prey, attracted to carcasses, occur [Kuyk, 1981 and Stenman, 1990]. At Schiphol, many experiment with both mounted or model gulls have been conducted [Blokpoel, 1976]. Various gull reactions, ranging from virtually no effect to a very strong reaction, have been noted. Posture and placing of the model appear to be important factors. Sitting or standing models do not deter gulls. Lying birds, with or without spread out wings, provoke a reaction similar to distress calls; flying towards the model, circling and flying away. The frightening effect may last 1 –3 months [Kuyk, 1981]; other sources report effectiveness lasting only one to a few days [Stenman, 1990]. Birds may settle down again within 50 meters of the dead bird. Models hung up are more frightening than when laying on the ground, probably because of the additional movement [Blokpoel, 1976]. Especially a nodding head-tail movement has been successful [Kuyk, 1981 and Stenman, 1990].

b) Falconry

The results with falconry vary in practice. Success of falconry depends on many factors; more analysis is needed to establish the effectiveness under various circumstances [.Several species of falcon (Peregrine, Gyr, Lanner or Saker Falcon or Merlin) and Eurasian Goshawk can be trained effectively for bird dispersal at airports. Not only low altitude hunting flights

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but also high altitude patrolling flights of raptors are successful in chasing away birds. An advantage is that the falcon is less vulnerable than when hunting. In this respect, falcons are more useful than goshawks, because the latter preferably uses fast low altitude flight [Dolbeer, 1998].

Falconry was or is practised in some countries with good results (e.g. Scotland, Canada [Blokpoel, 1976], Spain [Dolbeer, 1998]). At JFK Airport, falconry was tested to supplement (and eventually replace) the gull-shooting programme. Peregrine, Peregrine x Gyr falcon-hybrid and Harris' hawk were flown, typically in flights simulating hunting. Gulls will react mainly with formation flight [Lovell, 1997]. Additional pyrotechnics and distress calls were used. During overlap of shooting and falconry, less gulls were shot. When shooting was stopped and falconry was continued (received positively by public and media), there was, however, no significant reduction of bird strikes compared to the period prior to shooting. In other cases, falconry did not appear to be (cost) effective after testing. In the Netherlands, falconry was tested at Schiphol airport, in combination with model aircraft. It was used at Vliegbasis Leeuwarden until 1974 [Stenman, 1990]. An advantage is that habituation does not occur, because a real danger is involved. However, there are several limitations: training and maintenance is difficult, a full-time team is required, the birds can only be flown during daylight and good weather and fl ying is not possible just after feeding or during moult [Blokpoel, 1976; Godsey, 1997 and Kuyk, 1981]. In many cases, falconry was abandoned because of these limitations. When considering use or testing of falconry, the local situation and limitations should be taken into account.

XII. Killing

Population management aimed on an actual reduction of the total numbers of a bird species (other than on a local scale) implies that the killing rate must be higher than the natural death rate. Most target species tend to be very numerous or the numbers are increasing (e.g. gulls, waterfowl, Starling), so killing will show little effect in terms of numbers, unless practised on a very large scale. However, it has shown to be effective at local breeding colonies. Killing great numbers of birds is, apart from difficult an expensive, generally not an acceptable control method. Moreover, it may have an adverse effect. Decreasing numbers result in less competition between the surviving birds for resources, so the remaining population may well be 'healthier' [Cleary and Dolbeer, 2000]. In the Netherlands, population management at gull colonies is hardly practised, also because gulls generally do not cause many problems in the breeding season [Kuyk, 1981].In the case that birds are an acute danger, killing or capturing is used to immediately eliminate the threat. This method is widely used, often as a 'last option' in bird control [Klaver, 1999 and Stenman, 1990]. Captured birds are either relocated (birds of prey) or killed. There are various methods for killing or capturing which will be discussed below. The use will depend on the local situation, the applicable regulations and on social or political aspects. Killing individual birds as a reinforcement of repellent techniques is widely used and has proved to avoid habituation and to stimulate the scaring effect. This is mainly done by shooting. Leaving a carcass after shooting has proved to be very effective, the effect lasting 24 hours. However, care should be taken not to leave carcasses on or close to runways because they may attract predators or scavenging birds, or the carcass may itself be ingested in engines of passing planes. Lethal means of population management are shooting, lethal trapping, poisoning and destroying of eggs or nests. One example of introduction of predators was found. Relevant methods are discussed below.

XIII. Shooting

Shooting eliminates the target bird, frightens the rest of the flock and reinforces other repellent techniques. Surviving birds will be scared by the noise and the death of one bird, and will associate this with the other repellents. It can be very effective; at JFK International Airport for instance, bird strike was reduced to 90% by shooting gulls flying over the airport. These birds were mainly Laughing gulls, originating from an expanding breeding colony nearby; during a six year shooting period, 52,235 gulls were killed [Dolbeer, 1998]. Observations indicated that shot local breeders were replaced by birds immigrating from other (expanding) colonies [MacKinnon, 1997]. Apart from the disadvantage of killing many birds, shooting is expensive and demands a lot of effort. Professional use of fire arms, study of regulations and notification of local authorities are important aspects of this control method [Cleary and Dolbeer, 2000]. For waterfowl, hunting is a good way of reducing the local population as well as repelling ducks or geese [Dolbeer and Bucknall, 1994]. Gulls tend to learn very quickly and will soon react to approaching vehicles or people by keeping a safe distance; out of shooting range (this behaviour causes the reinforcing effect of shooting on harassment). Thus, shooting gulls may soon become very difficult, unless it is practised on birds flying overhead on a sleeping or feeding fly route [Dolbeer, 1998 and Kuyk, 1981]. Occasional shooting of individual birds is practised in many countries, depending on the applicable regulations. In the Netherlands, shooting at civil airports is only used as reinforcement of the usual techniques and to reduce the number of hazardous breeding species (Oystercatcher, Lapwing, Grey Heron,Pheasant).

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XIV. Trapping

Lethal traps are little used. An (American) example is a snap trap for woodpeckers damaging utility poles [Cleary, 1998]. Woodpeckers are generally not a problem species on airfields. Eurasian species of woodpecker are not likely to use poles and are rare around airports because of the lack of trees.

XV. Destruction of Eggs and Nests

Nearby breeding populations of waterfowl or gulls can be a problem. Breeding of gulls can be discouraged by removing their eggs and nests. As soon as clutches are complete, all eggs and nests should be removed from the colony every two to three weeks, continuing until all breeding efforts stop. Another possibility is to spray the eggs with an emulsion of oil in water containing 10% formaldehyde. The eggs will die of without decomposition (which may induce laying of a second clutch). [Kelly, 1999] mentions that this method is only workable in smaller colonies, although it was used effectively at a large Herring Gull colony near the airport of C openhagen [Stenman, 1990 and Inoue, (1999).]. Egg-shaking is also used. Shaking should start after the clutch is complete and breeding begins. When incubating is already progressed, shaking loses its effect. To determine the state of incubation, the flotation test is suitable. Eggs and nests should not be destroyed after shaking before another period of incubation have gone by (three weeks for waterfowl). After that period, birds will generally not attempt to re-nest [Dolbeer, 1995].

XVI. Predators

In the United States, Herring Gull colonies on small islands have been eliminated by introduction of fox and racoons within 2–4 years (predation of both birds and eggs). However, these predators were not able to survive without additional feeding. In contrast to colonies, the presence of predators at gull-roosts does not appear to be effective, because roosting birds will fly sooner than breeding birds. To prevent escape of predators and colonisation of adjacent terrain, areas where predators are introduced should be completely fenced of. In practice, this will be very difficult (except on islands). A general problem with introduction of predators is that they themselves have to be controlled, in order to maintain a certain population density. Also, the predators themselves may pose a strike risk to aircraft [Kuyk, 1981].

XVII. Chemical Capture

Chemical capture works by feeding target birds with bait treated with a sedative or immobilising toxicant, after which the birds can be captured. Recommended baits are corn (for groups of pigeons or waterfowl) and bread (individual birds). Alpha chloralose (A -C), for example, is used in the United States and on Herring Gulls in Denmark (here, however, in a lethal dose) [Stenman, 1990]. Birds become capturable within 30 to 90 minutes, recovery occurs within 8 to 24 hours. Pre-baiting is necessary to ensure the success of this method.

XVIII. Chemical Repellents

In the Netherlands, amongst other countries, chemical repellents are not used nor are experiments conducted. A number of chemical repellents are currently used in the United States and Australia [Cleary, 1998 and Stenman, 1990]. In many cases, experiments with chemicals to harass birds (mainly tried on gulls) have often been unsuccessful and if it was, a combination with other techniques was necessary to chase birds away [Kuyk, 1981 and Stenman, 1990]. Having a moderate climate with a lot of rain, chemicals are not expected to be successful in the Netherlands [Kuyk, 1981]. The use of potentially toxic chemicals may also have legal (and ethical) complications. Consequently, testing and use of chemicals as bird repellents is not recommended.

a) Reta

In Israel, surface spraying with Reta (aluminium ammonium sulphate) caused a decrease in the number of gulls; but the gulls did not disappear completely until this was combined with other measures. Although the gulls seemed to have become more uneasy and more susceptible to sounds, the use of Reta was not considered a sufficient method. In several other countries (Denmark, Switzerland, France), tests with Reta failed to produce good results [Kuyk, 1981 and Stenman, 1990].

b) Polybutene

The chemical repellents discussed below are registered in the United States. For keeping birds of roosting surfaces, a number of repellents containing polybutene or polyisobutylene are available. They are applied to the favoured surfaces inliquid or paste form and make birds feel uncomfortable when they land. In order to displace the birds effectively, all potential surfaces should be treated. Application should be repeated every half a year or year, but much more often if the surfaces are very dirty. Examples are Bird Stop, Roost-no-more, Bird-X, 4-The Birds, all of them non-toxic [Stenman, 1990].

c) Methyl anthranilate

Methyl anthranilate is the non-toxic active compound in ReJeX -iT, to which birds have a strong aversion. It is applied on golf courses, landfills, standing water and temporary pools to keep away gulls, waterfowl or Starling [Cleary and Dolbeer, 2000]. Although the effectiveness of methyl anthranilate has

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been demonstrated on several bird species (Ring-billed gull, Mallard [.Dolbeer *et al*. 1993]), experiments on (captive) Canada geese foraging on turf showed no evidence that ReJeX -iT was effective as a grazing repellent. It may be more effective in higher doses and on wild Canada geese, particularly in combination with other forms of harassment. The effectiveness mayalso depend on the surface that is being protected; food demands higher concentrations of methyl anthranilate than water, for instance [Belant et al. 1996 and Dolbeer *et al*. 1993].

d) Naphthalene

This repellent, working on the sense of smell, was tested at airfields in the United Kingdom. It was applied to the field as 'moth balls'. Results were contradictory [Blokpoel, 1976].

e) Aminopyridine

Avitrol is an example of a toxic repellent. Bait (preferably grain) is treated with Avitrol and subsequently eaten by the target birds. They react on the active compound (4-aminopyridine) with distress behaviour, in turn frightening other birds in the vicinity. A sufficient dose will be lethal; by using limited amounts of bait, a flock of birds can be chased away with minimum mortality [Cleary and. Dolbeer, 2000].

XIX. Poisoning

For poisoning target birds, oral and contact toxicants are used, a.o. in the United States (they are not used in the Netherlands [Lensink and Dirksen 1999]. Experience with toxicants mainly has an agricultural background, but they are also used at airports. Oral toxicants are applied by baiting, contact toxicant by treating perches. They require a careful study of the target birds' behaviour, favoured sites, carefully designed pre-baiting, careful handling and controlling of toxicant and bai t. Pre-baiting is the determining factor for success. Location and timing of pre-baiting should be adjusted to the birds' feeding behaviour and daily routine, and should be conducted for two to three weeks before applying the toxicant. The bait should be of good quality and of fine, uniform structure (higher surface-volume ratio). It should not be applied before it is made sure that only target birds feed on the bait. Unused bait and dead birds should be properly removed An example of an oral toxicant (registered in the United States) is 3-chloro-p-toluidine hydrochloride, that is a.o. used for gulls at colonies to reduce predation of nearby nesting colonies of other species. It metabolises quickly, the metabolites are not toxic and there is no secondary toxicity to animals eating killed birds. An example of a contact toxicant (registered in the United States) is fenthion ('Rid-a-Bird' perches). It is used for Starling, pigeons and sparrows and applied on or in (farm) buildings, power plants, bridges etc. Secondary toxicity occurs so dead birds should be properly removed. It is not recommended to use perches outside building because non target birds may become a victim [Cleary, 1998]. There is an example of successful application of a strong sleeping drug in a gull colony in New Zealand, after which many birds were captured [Kuyk, 1981].

XX. Developing a Bird Control Program in Airports

In general, It is clear that the design of a bird control program should be proceeded by a study of ecology and behaviour of problem birds at the local and regional level. Preferably, the results will be taken into account when locating and designing a new airport. The first step towards effective bird control is answering the question why the birds are (or will be) attracted to the airport. The answer will be provided by identifying to what extent the environment offers food, cover and water. This implicates knowledge about the ecology of the target birds (and, possibly, their prey), the features of the environment and land use activities in the vicinity [MacKinnon, 1997 and Godsey, 1997] also stresses the importance of learning about local bird activities, through conducting bird surveys. These surveys should include weather conditions, species, location, flying and other activities and possible attractants. [Cleary, 1998] mentions questions that should be answered next:

1. Which bird species are causing the damage?
2. What are the birds doing that make it necessary to control them or their damage? The answer to this question will, to a large extent, determine the control methods used.
3. What is the legal status of the problem birds?
4. What are the daily movement patterns of the birds between their feeding, loafing and roosting areas? When are they most vulnerable in their movement cycles?
5. What effective and legal control methods are available?
6. How selective are these control methods? The object is to control only the target birds, not all birds in the area.
7. How much will it cost to apply the selected control methods (also in relation to the costs of the damage)?
8. How does the public feel about the birds, their damage and the control implications?

A number of these questions may be of less relevance, when compared to the risks involved (for instance, the legal status of birds or the public feeling). Bird control measures (and their costs) should be compared to an assessment of the risks to safety. Several authors stress the fact that, apart from control techniques, monitoring of bird strike is a very important way of gathering information, assessing risks and

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developing bird control measures fit to the local situation. It is suspected that many strike events remain unreported. Reporting bird strike is being strongly promoted by the several bird strike committees [Bird Strike Committee USA, 1999 and National Wildlife Research Centre, 1999].Using this information will facilitate the assessment and modelling of the risk of bird strike [Bird Strike Committee USA, 1999]. A guideline for developing a wildlife management plan is under preparation.

Special attention should be paid to bird hazards from the start. An island at sea will always constitute a strong attraction to many birds. The attraction can be influenced by design, habitat manipulation and exclusion and repellent or dispersal techniques, be it only partly. In order to provide sufficient safe conditions for aviation, bird control should be very strict, for instance including absolute zero-tolerance policy towards (breeding) gulls and Cormorants. However, migrating or sheltering birds can hardly be controlled by bird control measures. An adequate observation and warning system may be necessary. Especially during migration and winter, bird hazards can well be such that flight operations may have to be intermitted.

Zoning around an airport at sea takes a rather different perspective compared to airports inland. Restrictions on 'land' use do not seem to apply, however, certain activities, like commercial fishing, require special attention. Large numbers of gulls may follow fishing boats, usually flying at low altitude and is very useful as a sheltered look -out for approaching boats.

At night, an airport-island at sea will also be an island of light. Whereas special lights have been used for repelling birds, they will rather attract birds at sea (whether flashing or not), especially nocturnally migrating passerines. Vegetation management requires special attention, because the island will start off with bare sand. Sand dunes are dynamic and will shift rapidly under the windy circumstances. Measures will be needed to keep runways and hard surface free of sand, and vegetation will be the most important. In coastal areas, grass ('Helmgras') is generally used. However, Herring, Black-backed and Common gulls use this habitat when breeding in dunes. Pioneervegetations on flat coastal sands are generally scanty and short, thus being attractive as

Roosting and loafing habitat. Creating a closed grass vegetation will be very difficult Thorn scrub ('Duindoorn') grows well in this habitat and may be an alternative, despite its attraction to migrating passerines (for cover and berries). These small migrants are generally not abundant out at sea (except in the occasion of a fall), they tend to stick to cover and do not fly around much, thus being less hazardous than roosting gulls. Audio and visual repellents that have proven to be effective should be tested in the field situation. Depending on test results, techniques may be adjusted or altered. Chemical repellents may be tested as well, although legal or environmental concerns may arise. Moreover, many chemicals have proven to be unsuccessful and may be especially so in the wet and windy circumstances on an island.

a) Recommendations of Bird Control in Egyptian Airports

A number of measures can be mentioned as being important and/or potentially useful. These are:

1. design and management of lay-out, vegetation and other terrain on the airport
2. management of fresh water (drainage, rain)
3. handling of potential food sources and waste disposal
4. regulations for commercial fishing around the airport
5. exclusion measures
6. continuous bird patrol
7. pyrotechnics and bioacoustics
8. shooting
9. discouragement and destruction of breeding attempts (zero tolerance)

With respect to the rather unique situation of an airport, several aspects will require more research. Also, other aspects deserve interest that are usually not or less relevant in the case of an airport inland. A number of aspects can be mentioned in this respect (some of which are already subject to current studies):

1. preferred distance from the coast with respect to migration patterns and attracting coastal birds
2. behavior of birds (gulls) at and around Egypt
3. sea-migration patterns around Egypt
4. effects of creating nearby Egypt attractive to birds, to keep them away from the airport island
5. design of the Egypt with respect to birds migrating across the sea
6. field tests on the development of (preferred) vegetation under coastal conditions
7. minimising the creation of sheltered bays or lagoons
8. exclusion measures along shores, buildings and at sheltered sites on and around Egypt

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Combined Control Scheme for Monitoring Quality Characteristics

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Abstract- In the literature, the Exponentially Weighted Moving Average (EWMA) and Exponentially Weighted Moving Variance (EMWV) control schemes have been used separately to monitor the process average and process variability respectively. Here the two are combined and applied on simulated process with different level of variation. The control limit interval (CLI) and the average run length (ARL) were evaluated for the combined chart. The combined chart performed better than the two independently. Furthermore, an algorithm was developed for the two control charts and implemented on visual basic VB6.0. The obtained results show that the combined EWMA and EWMV control chart is very sensitive in detecting shift in production process and every shift in the process mean is always preceded by shift in the process variability.

Keywords: statistical process control, control chart, exponentially weighted moving average (ewma), exponentially weighted moving variance (emwv).

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Combined Control Scheme for Monitoring Quality Characteristics

Adekeye K. S [α] & Bada Olatunbosun [σ]

Abstract- In the literature, the Exponentially Weighted Moving Average (EWMA) and Exponentially Weighted Moving Variance (EMWV) control schemes have been used separately to monitor the process average and process variability respectively. Here the two are combined and applied on simulated process with different level of variation. The control limit interval (CLI) and the average run length (ARL) were evaluated for the combined chart. The combined chart performed better than the two independently. Furthermore, an algorithm was developed for the two control charts and implemented on visual basic VB6.0. The obtained results show that the combined EWMA and EWMV control chart is very sensitive in detecting shift in production process and every shift in the process mean is always preceded by shift in the process variability.

Keywords: statistical process control, control chart, exponentially weighted moving average (ewma), exponentially weighted moving variance (emwv).

I. Introduction

Statistical Process Control (SPC) scheme are extensively used to detect process excursions and thus prevent the production of defective products as quality of products today is in the centre of attention worldwide. There are several forms of process variation, but process means shifts are the primary focus of most control chart design. The Shewhart control chart (e.g. $\overline{X}$, R, P, C-chart e.t.c) so named after the pioneering work of Dr Walter Shewhart, have wide acceptability in industries, it can be shown that, if there are sharp, intermittent changes in a process, these types of charts are highly effective in detecting them. However, if one is interested in small persistent shift in a process, other types of control chart may be preferred, for example, Exponentially Weighted Moving Average (EWMA) control charts originally described by Robert(1959), and Exponentially Weighted Moving Variance (EMWV) control charts as advocated by Montgomery and Mastrangelo(1991).

EWMA and EWMV charts are becoming much better popular among the practitioners because of their superior ability to detect small process shift (Narinderjit Singh 2006). The EWMA and EWMV procedures will usually give tighter process control than the classical quality control schemes such as Shewhart schemes, because EWMA and EWMV procedures give an early indication of process changes, this is consistent with a management philosophy that encourages doing it right the first time(Adekeye2009).

An exponentially weighted moving average is a moving average of past data where each data point is assigned a weight. These weights decrease in an exponentially decaying fashion from present into the remote past, thus the moving average tends to be a reflection of the more recent process performance, because most of the weight is allocated to the most recently collected data. The amount of decrease of the weights is an exponential function of the weighting factor, (λ) which can assume values between 0 and 1. Exponentially weighted moving variance is a moving variance of past data that is equally having a weight attached.

Exponentially weighted moving averages will gradually depending on the weighting factor, move to the new mean of the process if a shift in the mean occurs, while the exponentially weighted moving variances will remain unchanged. If there is a shift in the process variability, the exponentially weighted moving variances will gradually move to the new level while the exponentially weighted moving averages still vary about the process mean.

The Shewhart control schemes for mean and range provide information on variability of the quality characteristics, consistency of performance and the mean of the quality characteristics, however Shewhart control scheme are only efficient in detecting large shift value in process mean and process variability. The (EWMA) control schemes can be designed to quickly detect small shifts in the mean of process, (Macgregor and Harris 1990), and exponentially weighted moving variance (EWMV) control scheme is very efficient in detecting small shift in process variability. A combined EWMA & EWMV gives improved properties when shift in both process mean and process variability are to be detected.

This work focus on combining Exponentially Weighted Moving Average (EWMA) control scheme and Exponentially Weighted Moving Variance (EWMV) control scheme to detect shifts in the mean and the variance of a simulated process.

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II. Methodology

a) Formulation of the EWMA and the EWMV charts.

For a sequentially recorded observations, which can either be individually observed values (X_t) from the process or sample averages ($\overline{X}_t$), the formulation of the EWMA and the EWMV charts are given below.

The EWMA chart:

$$Z_t = \lambda Q_t + (1-\lambda)Z_{t-1},\ 0 < \lambda \leq 1,\ t = 1, 2,\ldots,n \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1.0)$$

$$CL = \overline{X} \quad (2.0)$$

$$LCL = \overline{X} - 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}} \quad (3.0)$$

$$UCL = \overline{X} + 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}} \quad (4.0)$$

Where: Z_t is the value plotted on the control chart and is a weighted average of all previous plotted values

Z_0 is the estimated process mean and a starting value for the EWMA

λ is a smoothing parameter

Q_t is the sequentially recorded observations (which can either be individually observed values (X_t) from the process or sample averages ($\overline{X}_t$) obtained from a designated sampling plan).

σ is the standard deviation of the observations

The EWMV chart:

$$V_t^2 = \lambda(Q_t - Z_t)^2 + (1-\lambda)V^2_{t-1},\ 0 \leq \lambda \leq 1,\ t = 1,2,\ldots,n \quad (5.0)$$

$$CL = \sigma 2 \quad (6.0)$$

$$LCL = \sigma^2 - 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}} \quad (7.0)$$

$$UCL = \sigma^2 + 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}} \quad (8.0)$$

Where: V_t^2 is exponentially weighted moving variance

V_0^2 is the variance of the individually observed values or the sample averages.

Q_t is the sequentially recorded observations (which can either be individually observed values (X_t) from the process or sample averages ($\overline{X}_t$) obtained from a designated sampling plan).

Z_t is the corresponding EWMA value

λ is EWMV weighting parameter

An algorithm is developed to compute EWMA and EWMV statistics from the observed values or the sample averages and using the algorithm, a source code for computing EWMA and EWMV statistic is written in VB6.0 and used to compute the statistics taking into consideration the procedures described above.

The algorithm is as follows;

1. Initialize variable
   - 1.1 Set counter = 0
   - 1.2 Set sum of X = 0
   - 1.3 Set mean of X = 0
2. Open "data.txt"
3. Loop while end of file "data.txt" = false
   - 3.1 Set counter = counter + 1
   - 3.2 Read X from file "data.txt"
   - 3.3 Array Data (counter) = X
4. Close file (data.txt)
5. Set counter = 0
6. Loop while counter ≤ upper bound of ArrayData
   - 6.1 Set counter = counter +1
   - 6.2 Set sum of X = sum of X + ArrayData(counter)
7. Mean of X = sum of X/counter
8. Set counter = 0
9. Set sum of X = 0
10. Loop while counter ≤ upper bound of ArrayData
    - 10.1 Set counter = counter + 1
    - 10.2 Set Sum of X = Sum of X + (ArrayData(counter) – Mean of X)**2
11. End loop
12. Set V0 = Sum of X/(counter -1)
13. Set Z0 = Mean of X
14. Open "ComputedData.txt"

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15. Set Counter = 0
16. Loop while counter ≤ upper-bound of ArrayData
    16.1 counter = counter + 1
    16.2 EWMA = lamda*ArrayData(counter) + (1-lamda)*Z0
    16.3 EWMV = lamda*(ArrayData(counter)-EWMA)2 + (1-lamda)*V0
    16.4 Write counter, ArrayData(counter), EWMA, EWMV into file
    16.4.1 "ComputedData.txt"
    16.5 Set Z0 = EWMA
    16.6 Set V0 = EWMV
17. End loop
18. Close file "ComputedData.txt"
19. Stop.

b) Choosing The Value of The Weight Parameter(λ)

Various approaches have been proposed for choosing the value of λ. Lucas and Saccucci (1990), states that the choice "can be left to the judgment of the quality control analyst" and points out that the smaller the value of λ "the greater the influence of the historical data". Furthermore, smaller values of λ should be used if early recognition of smaller shifts is desired.

If λ = 1, the EWMA control chart degrades to the usual Shewhart $\overline{X}$ chart. Thus the larger the value of λ the more the weight assigned to the recent data and the shallow the memory of the EWMA. The smaller the value of λ, the more the weights given to older data and the deeper the memory of the EWMA. In order to see the influence of the weighting factor on the control charts, different value λ was applied on the simulated process in this study.

c) Simulation Process

Simulation is the use of mathematical model to recreate a situation, often repeatedly, so that the likelihood of various outcomes can be more accurately estimated. Simulation has also been defined as the use of a system model that has the designed characteristics of reality in order to produce the essence of actual operation by Gupta and Hira(2012).

We simulate a process that is normally distributed, the model is given as;

$$f_{(x)} = f_{(x:\mu,\sigma^2)} = \frac{1}{\sqrt{2\pi\sigma^2}}\ \ell^{-\frac{1}{2}\left[\frac{x-\mu}{\sigma}\right]^2}, -\infty \le x \le \infty, \mu \ge 0, \sigma \ge 0 \qquad (9.0)$$

Three different levels are considered for the variance σ^2:

(i) Small variation: $\sigma^2 = 0.268$
(ii) Medium variation: $\sigma^2 = 2.144$
(iii) Large variation: $\sigma^2 = 4.288$

And μ = 75 is set to simulate 200 cases.

d) Computation of ARL

The average run length (ARL) at a given level is the average number of samples taken before an action signal is given. If the process monitoring scheme employs only the single alarm rule "signal the first time that a point Q plots outside control limits," and the process is stable , the values Q_1, Q_2, Q_3,…. . Can be modeled as random draws from a fixed distribution (Stephen 2011), then using the notation

$q = P(Q_1$ plots outside control limits)

and ARL $= \frac{1}{q}$

e) Control Limit Interval (Cli)

The control limit interval (CLI) is the difference between the upper control limit and the lower control limit. The lower the value of CLI the better the performance of the control scheme (Adekeye 2012)

The CLI for EWMA is

$CLI_{EWMA} = UCL - LCL$

$$= \left(\overline{X} + 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}}\right) - \left(\overline{X} - 3\sigma\sqrt{\frac{\lambda}{(2-\lambda)}}\right)$$

$$= 6\sigma\sqrt{\frac{\lambda}{2-\lambda}}$$

And the CLI for EWMV is

$CLI_{EWMV} = UCL - LCL$

$$= \left(\sigma^2 + 3\sigma\sqrt{\frac{\lambda}{2-\lambda}}\right) - \left(\sigma^2 - 3\sigma\sqrt{\frac{\lambda}{2-\lambda}}\right)$$

$$= 6\sigma\sqrt{\frac{\lambda}{2-\lambda}}.$$

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III. Results

The EWMA &EWMV control charts are presented below in Figure 1 to Figure 6 for the simulated process with small variation, Figure 7 to Figure 12 for the simulated process with medium variation and Figure 13 to Figure 18 for the simulated process with large variation. The Average Run Length (ARL) and the Control Limit Interval (CLI) were computed for EWMA and EWMV control charts. The summary of CLI and ARL are presented in Table 1 and Table 2 respectively.

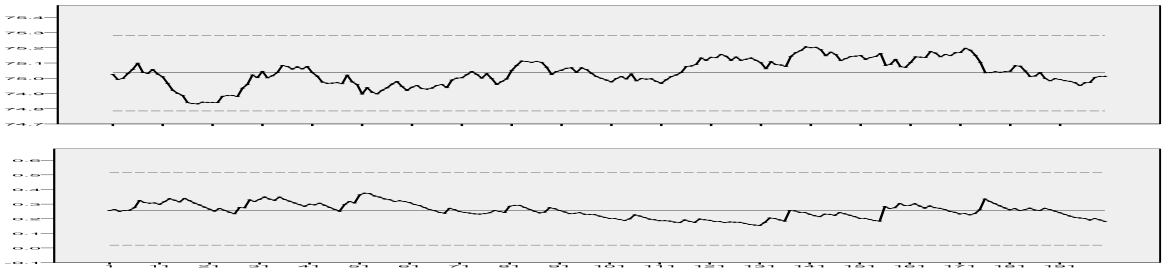


Figure 1 : EWMA & EWMV Control Charts for Simulated Data with Small Variation (Var = 0.268 & λ = 0.05)

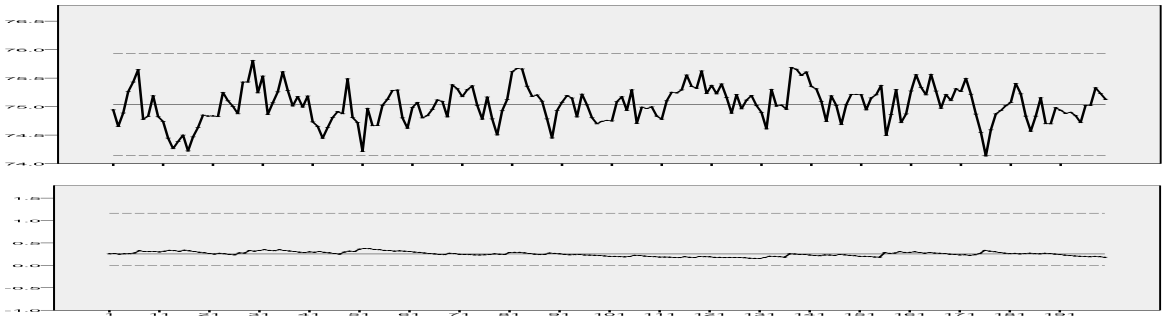


Figure 2 : EWMA & EWMV Control Charts for Simulated Data with Small Variation (Var = 0.268 & λ = 0.5)

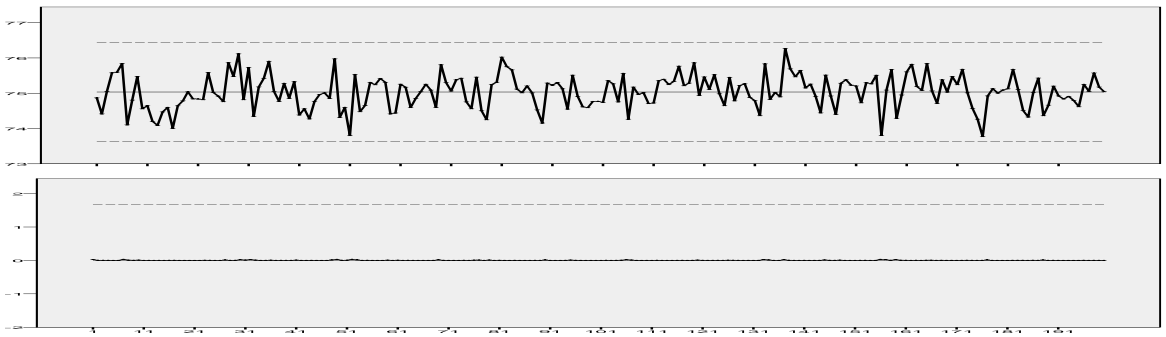


Figure 3 : EWMA & EWMV Control Charts for Simulated Data with Small Variation (Var = 0.268 & λ = 0.9)

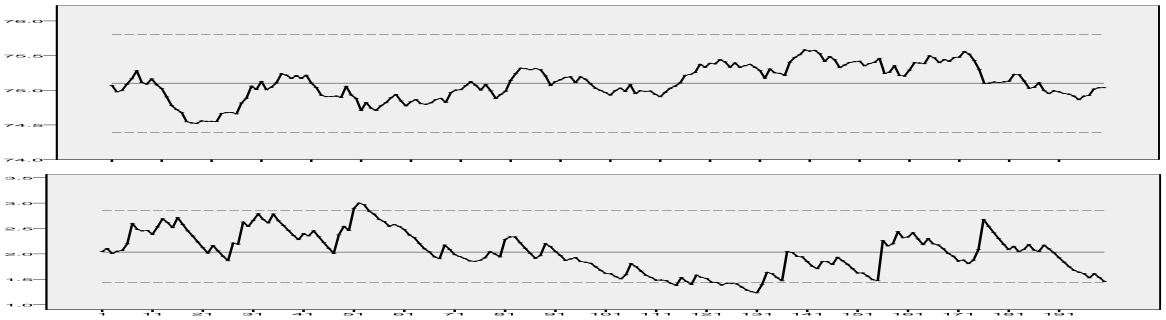


Figure 4 : EWMA & EWMV Control Charts for Simulated Data with Medium Variation (Var = 2.144 & λ = 0.05)

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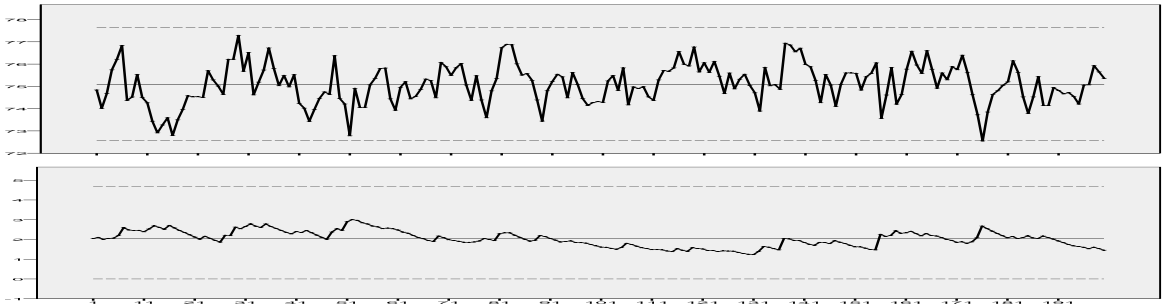


Figure 5 : EWMA & EWMV Control Charts for Simulated Data with Medium Variation (Var = 2.144 & Λ = 0.5)

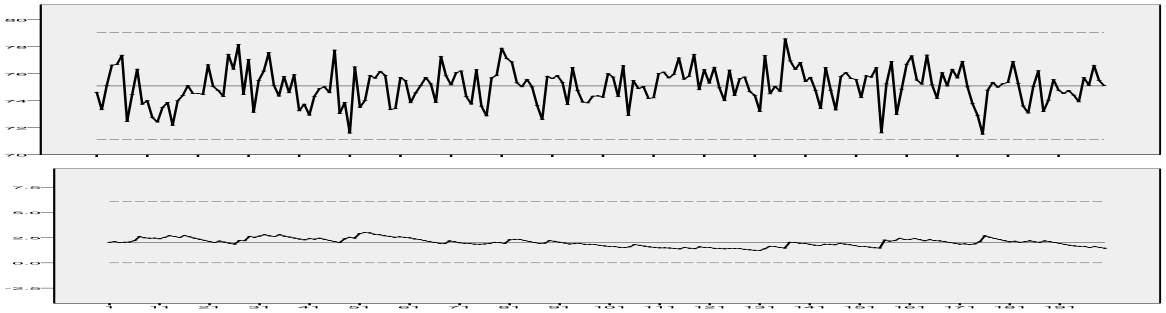


Figure 6 : EWMA & EWMV Control Charts for Simulated Data with Medium Variation (Var = 2.144 & Λ = 0.9)

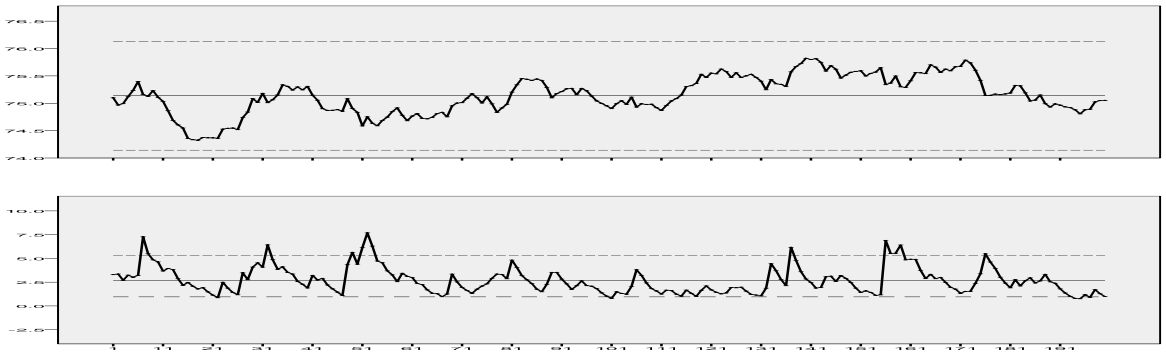


Figure 7 : EWMA & EWMV Control Charts for Simulated Data with Large Variation (Var = 4.288 & Λ = 0.05)

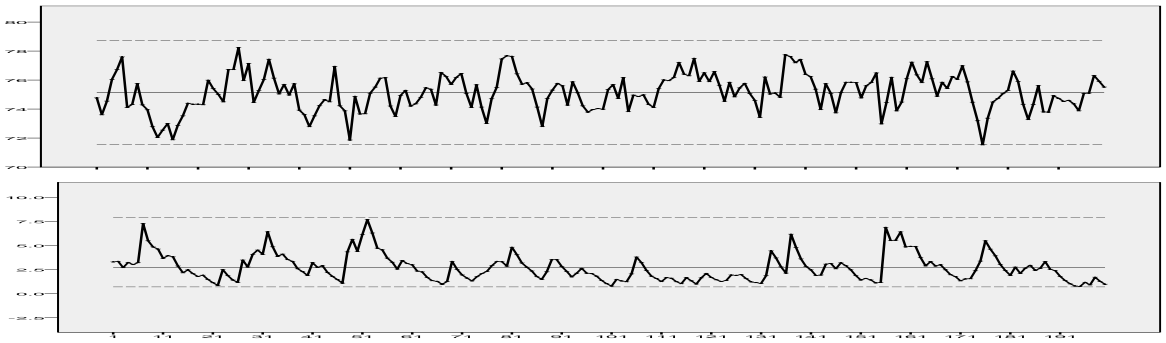


Figure 8 : EWMA & EWMV Control Charts for Simulated Data with Large Variation (Var = 4.288 & Λ = 0.5)

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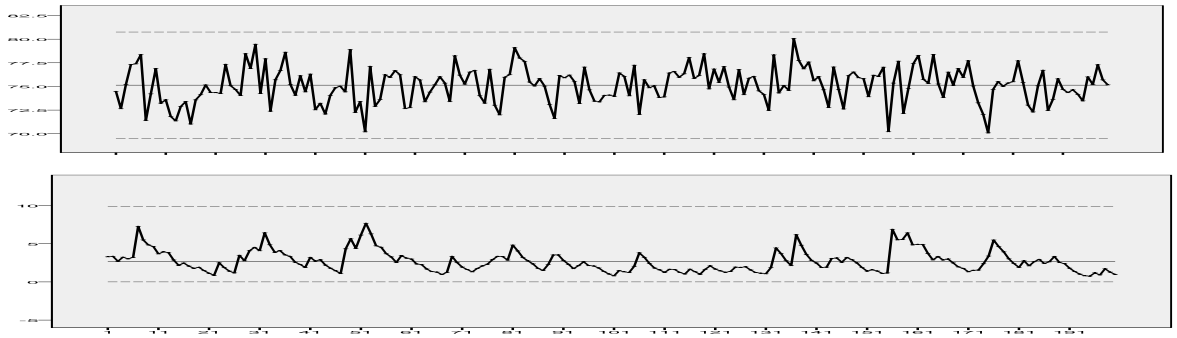


Figure 9: EWMA & EWMV Control Charts for Simulated Data with Large Variation (Var = 4.288 & Λ = 0.9)

Table 1 : Cli For EWMA & EWMV Control Chart

		λ					
		0.050	0.100	0.250	0.500	0.750	0.900
σ	0.518	0.500	0.715	1.175	1.793	2.409	2.810
	1.464	1.388	2.020	3.320	5.068	6.808	7.940
	2.071	2.000	2.858	4.697	7.170	7.456	11.233

The values in Table 1 shows the various value of CLI for the selected values of the weighting parameter (λ) for small variation, medium variation and large variation. The nomogram of which is presented in Figure 10.

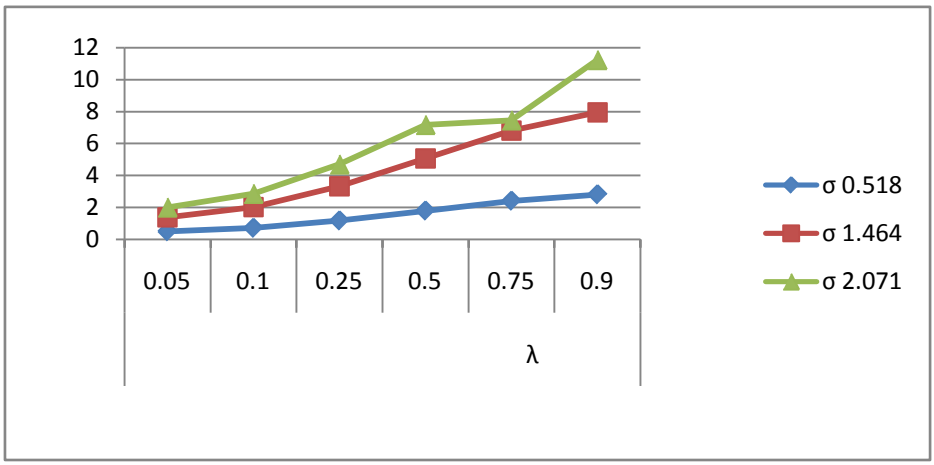


Figure 10 : CLI curve for EWMA&EWMV chart

Table 2 : Average Run Length (ARL) for EWMA control chart

	Λ					
	0.05	0.10	0.25	0.50	0.75	0.90
ARL	2	2	4	12	49	147

The values in Table 2 shows the various value of ARL for the selected values of the weighting parameter (λ), the nomogram of which is presented in Figure 11.

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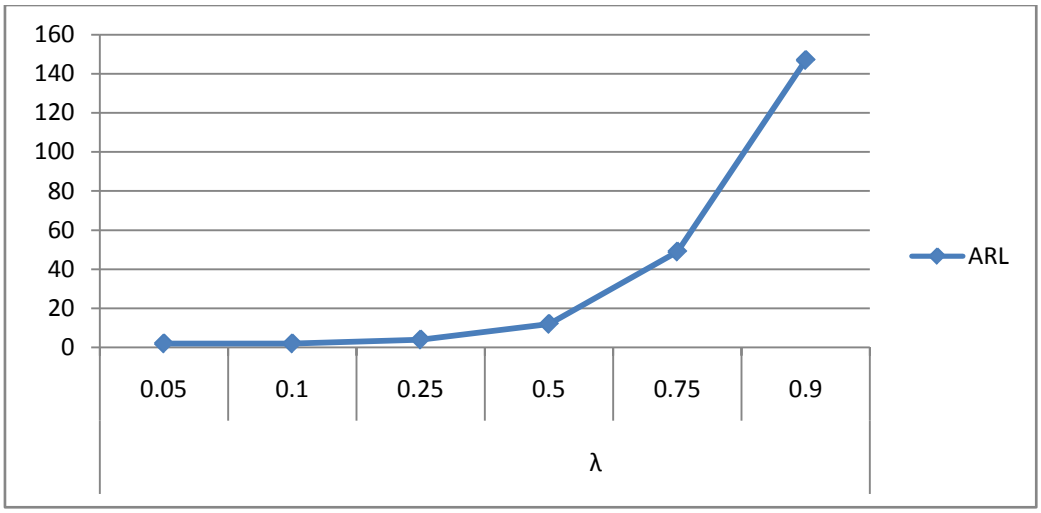


Figure 11 : ARL curve for EWMA control chart

IV. Discussion of Results

The results of the application of the combined EWMA & EWMV control scheme on the simulated process shows that shift in the process average is always preceded by a shift in the process variability as evident in the combined charts presented above and generally speaking, smaller value of the weighting factor seems more sensitive in recognizing shift in simulated process quality characteristics. The result on Table 2 shows that the CLI for small value of weighting factor (λ) is lower than that of high value of the weighting parameter. The results however show that the CLI for EWMA and EWMV chart are influenced by the size of variation and we conclude that small value of the weighting parameter (λ) on simulated process with small variation produces small value of CLI. The result on Table 1 shows that the ARL for small value of weighting factor (λ) is lower than that of high value of the weighting parameter and the curve of the ARL for EWMA in Figure 20 shows that EWMA chart is more sensitive to shift when the weighting parameter is small. In combined EWMA&EWMV control scheme, the process is adjudged to be stable if both the process average and variability is Stable, if any of the two is out of control, the process is considered to be out of control.

V. Conclusion

The Combined EWMA & EWMV control scheme has been proposed as alternative means of monitoring process variation, analyzed by varying the weighting factor. The results show that the combined EWMA & EWMV control chart is very sensitive to small shift in the process mean and process variability.

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Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

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Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

A

Adipose · 23, 25, 26, 27
Alleviation · 17
Anthranilate · 39, 40, 41

B

Bioacoustics · 36, 37, 41

F

Falconry · 37, 38

G

Gerais · 12

H

Hyphae · 3

K

Kluyveromyces · 13, 14

L

Lactose · 13, 14, 17

M

Maneuvering · 35
Marxianus · 13, 14
Mycelium · 3

N

Nocturnally · 41

O

Oystercatcher · 37, 38

P

Peristaltic · 5
Photovoltaic · 20



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