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Numerical Simulation of Y-Internal Shaped Cavity

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Abstract. Current study outlines the effects of employing a Y-shaped cavity on the constructive design of a conducting wall. The trapezoidal body has a wide variety of industrial implications especially in micro-electronic devices. By manipulating the geometric aspect ratios of the cavity and the wall and by fixing the total volume occupied by the solid and the cavity, the optimization process is handled. The purpose of this paper is minimizing the peak temperature by following the optimization procedure. The numerical simulation results obtained by finite element method reveals that thermal performance of Y-shaped cavity, compared with rectangular shaped cavity has more superiorities.

Key words: Geometric optimization, Cavity, Numerical simulation, micro-electronics

1. INTRODUCTION

One issue that recently has attracted the attention of researchers is constructive design of the open “Cavities”. Open cavities are the regions formed between adjacent fins and stand for the essential promoters of boiling or condensation: see, for example, the Vapotron effect (Lorenzini et al., 2009) that occurs as a consequence of the thermal interaction between a non-isothermal finned surface and a fluid locally subjected to a transient change of phase. In the field of thermal design, Rocha et al. (2005) proposed constructive design of a rectangular cavity intruding into a conducting trapezoidal solid with uniform internal heat generation for the first time. They optimized the trapezoidal body and the rectangular cavity geometric aspect ratios in order to achieve the maximum thermal performance namely the minimum overall thermal resistance between the volume of the entire system (cavity and solid) and the surroundings. Later, Rocha et al. (2010) studied four shapes of cavity: rectangular, elliptical, triangular and a T-shaped cavity penetrated into a rectangular, solid, conducting wall with uniform internal heat generation. They demonstrated that the rectangular cavity performs better than the elliptical and triangular ones. C-shaped and H-shaped cavities were proposed by Biserni et al. (2001). They proved that the performance of the H-shaped cavity is better than C-shaped, T-shaped and rectangular cavities. Lorenzini and Biserni (2006) optimized the geometry of a Y-shaped cavity embedded into a solid conducting wall. The performance of the Y-shaped intrusion proved to be superior to that of other basic geometries such as T-shaped and C-shaped cavities.

Lorenzini and Rocha (2009) focused on a T-Y-shaped cavity in a rectangular wall with uniform heat generation on the solid wall. Later, Lorenzini et al. (2012) considered the geometrical optimization of a complex cavity, namely a T-Y-shaped cavity with two additional lateral intrusions into a solid conducting wall and demonstrated that the new complex cavity is superior to the basic T-Y-shaped cavity. To conduct an extended investigation, Rocha et al. (2007) considered the case where heat transfer on the internal surface of a C-shaped cavity was accounted for by a constant heat transfer coefficient unlike, that assumed isothermal cavities. Xie et al. (2010) determined the optimal aspect ratios of a T-shaped cavity intruded into a trapezoidal solid wall with uniform heat generation by applying constructal theory.

Although several works have been devoted to design the optimal shapes and structures of cavities intruding to the solid heat generating bodies, a few works among them have so far focused on the trapezoidal solids. Since trapezoidal heat generating solids can be assembled into “round” constructs such as hexagons, with which one can cover an entire 2D domain, it is noteworthy to study the design of cavities with different shapes intruding to a trapezoidal heat generating solid to fill the present gap in the field.

In this paper, a Y-shaped cavity intruding to a trapezoidal heat generating solid is studied. Optimization procedure consists of two steps; at the first step, optimal geometric aspect ratios of the trapezoidal solid and the cavities with a given shape is determined. The optimization objective is to minimize the overall thermal resistance between the volume of the entire system (cavity and solid) and the
surroundings. In the next step, the optimized cavity for the studied shape is compared with rectangular one so that the superior shape can be revealed. The described optimization procedure is carried out by using a finite elements approach of MATLAB PDE Toolbox to numerically calculate the temperature fields in the fin.

![Fig. 1: Y-shaped cavity intruding into a two-dimensional heat generating solid](image)

**Fig. 1:** Y-shaped cavity intruding into a two-dimensional heat generating solid

![Fig. 2: The minimization of the hot spot temperature with respect to \( \frac{H}{L} \) for several values of \( \frac{He}{H} \)](image)

**Fig. 2:** The minimization of the hot spot temperature with respect to \( \frac{H}{L} \) for several values of \( \frac{He}{H} \)

2. PROBLEM DEFINITION AND MATHEMATICAL FORMULATION

Consider two-dimensional conducting body intruded by Y-shaped cavity as sketched in Fig. 1. The total volume occupied by the entire body (cavity and solid) is fixed, and given by

\[
V = (H_e + H) LW/2 = \text{const.} \tag{1}
\]

Where, \( H \) and \( H_e \) are the two heights of the trapezoidal conducting solid, \( L \) is the length of the body, and \( W \) is the thickness of the body, which is perpendicular to the plane of Fig. 1. The external dimensions \((H, H_e, L)\) of solid wall and the dimensions of cavities \((H_0, H_0e, L_0, L_0e)\) are free to vary. The inclined edges of the trapezoidal and Y-shaped cavities are assumed parallel to those of the solid body. For the sake of simplicity, the changes of all parameters along the \( W \) dimension are assumed negligible. Thus, the area \( A = (H_e + H) L/2 \) can also be considered fixed. The cavities volume is fixed as well. The described area/volume constraints are expressed by the relations,

\[
\phi = \frac{V_0}{V} = \frac{2(H_0 + 2H_0e + L_0e)}{(H_e + H)L} = \text{const.} \tag{2}
\]

Where, \( \phi \) represents the volume fraction occupied by the cavity. The solid is assumed isotropic with constant thermal conductivity \( k \), and generates heat uniformly at the volumetric rate \( q''' [W/m^3] \). The outer
surfaces of the heat generating body are perfectly insulated. The generated heat flow per unit length \( (q'')A \) is removed by cooling the wall of the cavity. Due to the solid conduction resistance, temperature level in the solid rise to levels higher than \( T_{\text{min}} \) such that the highest temperatures (the hot spots) are registered at points on the insulated perimeter, for example, in the two corners labeled by \( T_{\text{max}} \) in Fig. 1. The hot spot's temperature of the solid may exceed the allowable temperature level. Knowing that, the performance of equipment has a direct relationship with its temperature, it is important to keep it at an acceptable temperature level. This is synonymous to make \( T_{\text{max}} \) a constraint. Therefore, the design objective is represented by the maximization of the global thermal conductance, \( \frac{q''A}{T_{\text{max}} - T_{\text{min}}} \), or by the minimization of the global thermal resistance \( \frac{T_{\text{max}} - T_{\text{min}}}{q''A/k} \).

Symmetry allows us to perform calculations in only half of the domain, \( y \geq 0 \). The 2-D conduction equation for the domain occupied by the heat generating solid under steady-state condition is,

\[
\frac{\partial^2 \tilde{T}}{\partial x^2} + \frac{\partial^2 \tilde{T}}{\partial y^2} + 1 = 0. \tag{3}
\]

Where the dimensionless variables and parameters are defined as,

\[
\tilde{T} = \frac{T - T_{\text{min}}}{q''A/k} \tag{4}
\]

The optimization objectives can be expressed in the dimensionless form as the minimization of,

\[
\tilde{T}_{\text{max}} = \frac{T_{\text{max}} - T_{\text{min}}}{q''A/k}. \tag{5}
\]

3. SOLUTION

The governing partial differential Eq. (3), is solved numerically using the finite elements analysis of partial-differential-equations (PDE) toolbox of embedded in MATLAB [10]. As is customarily done, the appropriate mesh size is determined by means of successive refinements, until the strongest convergence criterion \( \left| \frac{T_{\text{max}}^{j+1} - T_{\text{max}}^j}{T_{\text{max}}^j} \right| < 10^{-4} \) is satisfied. Here, \( T_{\text{max}}^j \) stands for the hot spot temperature calculated using the current mesh size, and \( T_{\text{max}}^{j+1} \) corresponds to the hot spot temperature calculated using the next mesh size where the number of elements is increased by a fourfold factor. The optimization results are calculated by using a range between 10,000 and 45,000 triangular elements. For the verification of the present numerical work, the numerical results obtained using our code in MATLAB PDE are compared with those obtained by FIDAP package, in Table 1 for the case of \( H/L=0.6, \ H_0/L_0=1 \), and several values of \( H_e/H \).
4. RESULTS AND DISCUSSIONS

The effect of the geometric aspect ratios of a trapezoidal heat generating solid, \( H/L \) and \( H_0/L_0 \) on the hot spot temperature, is depicted in Fig. 2, for the Y-shaped cavity, when the aspect ratio of the cavity is fixed, \( H_0/L_0 = 1 \). It can be observed that there is an optimal \( H/L \), which minimizes the hot spot temperature, \( \tilde{T}_{\text{max}} \), at several values of \( H_0/H \). Figure (2) also shows that there is an alternative opportunity of optimization with respect to \( H_0/H \). Therefore, the results shown in Fig. 2 are summarized in Figs. 3, to address the optimal values of \( H/L \) namely \( (H/L)_{\text{opt}} \), and the minimized maximum temperature, \( \tilde{T}_{\text{max,min}} \) for a wide range of \( H_0/H \). The feasibility of a double-minimization of \( \tilde{T}_{\text{max,min}} \) is observed in Fig. 3. To clarify the preceding observation and to account for the effect of the internal aspect ratio of the cavities, \( H_0/L_0 \), a second level of numerical optimization is conducted. The scheme consists of the repetition of the preceding optimization procedure for a wide range of the internal aspect ratio of Y-shaped cavity, \( H_0/L_0 \), in Figs. 4. Hence, the double optimized values of \( H/L \) and \( H_0/H \), namely \( (H/L)_{\text{opt}} \) and \( (H_0/H)_{\text{opt}} \), plus the double minimized hot spot temperatures, \( \tilde{T}_{\text{max,min}} \), are highlighted in the Fig. 4. It is concluded from Fig. 4 that the thermal performance improves as the cavity shape becomes slender \( (H_0 < < L_0) \).

Comparison among the rectangular and Y-Shaped cavities intruding into the trapezoidal solid is presented in Fig. 5, where the double-minimized temperature is plotted as a function of the cavity’s aspect ratio, \( H_0/L_0 \). It can be seen for this figure that for all range of \( H_0/L_0 \), thermal performance of Y-shaped cavity is superior.

5. CONCLUSIONS

In the present study, Constructal theory is applied to optimize the configuration a trapezoidal solid conducting wall intruded by an isothermal cavity. A Y-Shaped intruding to a trapezoidal heat generating solid is studied. In the most fundamental sense, the maximum dimensionless excess temperature is minimized with respect to three degrees of freedom, two aspect ratios of the trapezoidal solid and aspect ratio of the cavity, under the constraints that the volumes of the total body and the cavity are fixed. In the optimization process, the finite element method is employed and the degrees of freedom are relaxed one by one. The numerical results prove that there are optimal geometric aspect ratios for the external shape.
of the trapezoidal solid and the internal shape of the cavity that maximize the thermal performance or minimize the hot spot temperature. It was realized that the thermal performance improves as the cavity shape becomes slender. This conclusion can result strategic in geometric design of the cavities. Finally, comparison among the rectangular and Y-Shaped cavities intruding to the trapezoidal solid is presented. It is revealed that in various ranges of $H_o/L_0$, the superior shape (with lower peak temperature) is Y-shaped cavity.

![Comparison among the rectangular and Y-shaped cavities intruding into the trapezoidal solid](image)

**Fig. 5:** Comparison among the rectangular and Y-shaped cavities intruding into the trapezoidal solid

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<th>Description</th>
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<td>$A$</td>
<td>Total area occupied by the body (solid and the cavity)</td>
</tr>
<tr>
<td>$A_0$</td>
<td>Total area occupied by the cavity</td>
</tr>
<tr>
<td>$H$</td>
<td>Height of the trapezoidal solid (right)</td>
</tr>
<tr>
<td>$H_e$</td>
<td>Height of the trapezoidal solid (left)</td>
</tr>
<tr>
<td>$H_0$</td>
<td>Height of the cavity</td>
</tr>
<tr>
<td>$k$</td>
<td>Conductivity of the fin</td>
</tr>
<tr>
<td>$L$</td>
<td>Length of the solid</td>
</tr>
<tr>
<td>$L_0$</td>
<td>Length of the cavity</td>
</tr>
<tr>
<td>$T$</td>
<td>Heat generation rate per unit volume</td>
</tr>
<tr>
<td>$T_{max}$</td>
<td>Local Temperature</td>
</tr>
<tr>
<td>$V$</td>
<td>Total volume occupied by the body (solid and the cavity)</td>
</tr>
<tr>
<td>$V_0$</td>
<td>Total volume occupied by the cavity</td>
</tr>
<tr>
<td>$W$</td>
<td>The third dimension width perpendicular to the paper</td>
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<tr>
<td>$x, y$</td>
<td>Cartesian coordinates defined in Fig. 1</td>
</tr>
<tr>
<td>$\phi$</td>
<td>The volume fraction occupied by cavity</td>
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**REFERENCES**


Arash Ghanbari obtained his Master's degree from Tarbiat Modares University in 2008 and his bachelor's degree from Iran University of Science & Technology (IUST) in 2005. He is currently the senior mechanical engineer at Research Institute of Petroleum Industry (RIPI) where he works on detail design of oil & gas projects and development of equipment technology.

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Full Length Research Paper

Pharmaco-epidemiological Studies on Self Medication and Drug Utilization Pattern in Chronic Diseases via Prescription Auditing

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Abstract. Prescription auditing, a sort of vigilance activity is an important tool in pharmaco-epidemiological studies to get a clear picture about rational usage of drug, widely prescribed drugs, extent of polypharmacy, and the most prevalent diseases in a particular area. With the changing dynamics of the lifestyle, behavioral pattern, socioeconomic and educational status an increasing trend of self medication observed in both rural and urban dwellers. Till yet there is no such report about the drug utilization pattern or extent of self medication practice in the Kharagpur area. A study was conducted in Kharagpur region of India (Block 1 and 2) to determine the drug utilization trend and practice of self medication in the prevailing disease conditions by prescription monitoring and exit interviews with pretested Performa on customers randomly visiting the pharmacies. Prescription auditing showed that disease prevalence was predominant in age group of 11.00±6.25–50.00±9.75 and comparatively less incidences in the pediatrics (1.00±1.05–5.00±0.79) and geriatrics (70.00±1.31–75.00±1.01). There was a predominance of infectious diseases like fever, cough and cold during the study period followed by asthmatic problems and gastrointestinal infections GIT infections in the surveyed area. Self-medication of asthma and GIT infections was more prevalent in urban population (60%, n=133) as compared to the rural population (33.89%, n=107). Easy availability of lifestyle drugs, enhanced education levels amongst urban population and economic hindrance to pay physicians fees, influences of peer groups, advices of pharmacists, difficulty to avail drugs from clinics in rural regions influenced self medication. Analgesics, antipyretics were the most widely used self medicating drugs in survey area.

Key words: Prescription auditing; vigilance activity; self medication; poly-pharmacy; drug utilization; asthma; GIT infections; analgesics; antipyretics

1. INTRODUCTION

Pharmaco-epidemiology refers to epidemiological studies of the clinical use of drugs, their effects and side effects in large population mass with the purpose of promoting cost-effective rational use of drugs so as to achieve better health outcomes of the common mass (Sjokvist and Birkett, 2003; Sills et al., 2009; Prasant et al., 2013). Prescription auditing or monitoring is an important mechanism to improve the quality of care afforded by the physicians both private practitioners and the public hospitals. It is a sort of vigilance activity which refers to the collection of prescriptions and gathering of information’s relating to widely prescribed drugs, extent of poly-pharmacy and the existing drug utilization pattern (Aitken et al., 2009; Abidi et al., 2012; Bhattacharya et al., 2012; Pohtaraju et al., 2011; Ndungu et al., 2007; Jyoti et al., 2013). Drug worth crores of rupees are consumed every year but a substantial amount of such drugs is irrationally prescribed (Abidi et al., 2012). Recent trends have shown increasing incidences of self-medication in both rural and urban populations. Self medication is the “use of drugs or Pharmaceutical products by the consumer to treat self recognized disorders or symptoms or the intermittent or continued use of the medication prescribed by the physicians for a chronic or recurring diseases or symptoms” (Widayati et al., 2011). Self medication is multi-factorial (Chawla et al., 2013; Bimo et al., 1995; Chaudhuri et al., 2011; Krishnaswamy and Kumar, 2005; Patel et al., 2012; Pisarik, 2010; Pandey et al., 2010). Unintentional administration of xenobiotics including heavy metals also affects human health along with irrational use of drugs (Saedi et al., 2013). Different socio-economic implications, unavailability of registered medical practitioners (RMPs) in remote areas, increasing cost of medical treatments, inability to pay physician’s fees, long waiting hours in clinics or other medical facilities, advices from peer groups and pharmacists greatly promotes self medication in rural areas. In urban areas, ready access to drugs from several medical stores, rapid growth of mass medias, television and newspaper advertisements, internet facilities and easy availability of lifestyle drugs are important.
contributing factors to self medications. However self medications can have far reaching consequences due to dangerous drug interactions and adverse effects; and emergence of resistance to chemotherapeutic agents (Chawla et al., 2013; Krishnaswamy and Kumar, 2005; Jyoti et al., 2013; Patel et al., 2012; Biswas et al., 2001). The study aimed at establishing the current trend of existing drug therapies in regular health problems, available treatment options for chronic diseases like asthma and prevalence of self-medication in Kharagpur (Block 1 and 2), West Bengal, India via prescription monitoring and as exit interviews using pretested Performa with randomly visiting customers in pharmacies of these areas.

2. MATERIALS AND METHODS

The epidemiological survey of prescription monitoring was carried out in three hospitals in and around IIT campus. Bidhan Chandra Roy Technology hospital (BCRTH), situated within the campus premises of IIT Kharagpur, India funded by IIT institute. Prembazar Rural hospital situated just outside the campus and Kharagpur State hospital with all medical departments funded by West Bengal government.

A two-year (1st March, 2011-1st March, 2013) prescription audit was carried out after taking consent of CMO to collect data from prescription records of patients visiting the out-patient department of the three hospitals. The study protocol was a modified version of prescription-monitoring Performa Annexure-2 recommended by WHO (Bimo et al., 1995). The parameters in the protocol Performa included demographic, anthropometric and therapeutic details of the individual patients. For assessment of self medication, patients attending the clinics of consultants and approaching the pharmacy stores were interviewed after taking their verbal consent during the same study period. Interviewed patients included were from rural and urban areas of Kharagpur. In the surveyed area local agents or field staffs appointed by the research team contacted the patients attending three pharmacies attached to the hospitals included in study as well as eleven community pharmacies in the adjoining areas of the three hospitals. In addition, for data collections regarding self medication the co-operation of the owners of the community pharmacies, appointed or working pharmacists were also sought by the research group.

The data were collected using the pre-designed Performa: (1) duration and details of illness, (2) signs and symptoms, (3) medicaments used for self medication, (4) reasons for self medications, (5) sources of advices as regards self medication, (6) medicaments concurrently used along with self medications along with the socio-economic and (7) demographic details of the patients. The detailed protocol is shown in Table 1.

After compilation, the data were classified in to different independent variables, tabulated and percentages were calculated. The statistical calculations like mean and standard deviations (±SD values) were done and Pie charts were plotted using Microsoft Excel-2007 Software. Analysis of 2X2 contingency tables was performed with the aid of GraphPad statistical software.

### 3. RESULTS AND FINDINGS

Amongst the collected prescriptions for the purpose of audit the results of demographic analysis of patients showed 58% male, 32% female and 10% child. Patient age-wise distribution of collected prescriptions showed that disease prevalence was predominant in age group of 11.00±6.25–50.00±9.75 and comparatively less incidence in the pediatrics (1.00±1.05–5.00±0.79) and geriatrics (70.00±1.31–75.00±1.01). Division of prescriptions according to duration, disease conditions and prescribed drug category are presented in Fig.1-3.

Prescription auditing showed predominance of infectious diseases followed by significant number of asthmatic incidences and GI-tract infections. Out of 100 prescriptions audited, poly-pharmacy was noticeable compared to single drug therapy. However in poly-pharmacy two drug combinations were mostly used than three or four drug combinations (Fig.4).
For assessing the prevalence of self medication, 225 responses were recorded of which 118 and 107 were from urban and rural population respectively. Out of total persons approached (n=225), the self-medication was predominant in female population (n=133; 59.11%) than that of male population (n=92, 40.8%), combinedly in rural and urban population. In urban areas (n=118), it was observed that 60% of drug purchasers were self-medicating based on drug information from television, news, advertisements and internet and 22% relied on pharmacist order and 11% of the drug purchasers were undergoing chronic treatment without prescription (advised by other layman) in contrast to those of rural areas (n=107), where it was observed that 33.89% were forced to go for self medication due to economic hindrances, 38.11% relied on Pharmacist’s advice, 22.11% were influenced by peer groups and only 5.89% were dependent on internets, drug advertisements etc (Fig.5-6). In rural areas persons self medicating mostly relied on pharmacist order and some drug purchasers were undergoing chronic treatment without prescription advised by other layman. Mostly widely used categories of drugs for self medication were: analgesics, anti-pyretics and antimicrobials. However sedatives and hypnotics were rarely used (Fig. 7). From the view point of self-medication over the counter (OTC) sale of antimicrobial drugs constituted mostly broad-spectrum antibiotics such as tetracycline, chloramphencolin, cotrimoxazole (80%). Other category of drugs sold were antifungal (10%), antimalarial (2.5%), anti-amoebic (2.5%), antiviral (2.5%) and anti-helmintic (2.5%). Statistical analysis of data showed prolonged intake of certain drugs for chronic diseases was 35.11±7.05%. About 27.11±6.34% were self medicating being guided by peer groups and drug advertisements; 12.89±4.65% being advised by paramedical staff; and 24.89±7.25% were compelled to self medicate due to economic hindrances to pay physician’s fees.

Further statistical analyses were done considering 2X2 contingency tables. Considering prescription duration Vs diseases chi-squared value (3.129) with one degrees of freedom and P value (one-tailed, 0.0384) showed association to be statistically significant and a two tailed P value of 0.0769 showed the association is not quite statistically significant. In case of prescription duration Vs drug category chi-squared value (2.780) with one degrees of freedom and P value (one-tailed, 0.0477) showed association to be statistically significant and a two tailed P value of 0.0954 showed the association is not quite statistically significant. For diseases Vs drug category chi-squared value (0.003) with one degree of the freedom and P values (one tailed, 0.477) and (two tailed, 0.953) was not considered statistically significant.

4. DISCUSSION

The present investigation was aimed at monitoring the drug utilization pattern of general therapy in out-patient department of three hospitals in Kharagpur area. In the study period (1st March,2011-1st March, 2013), prescription auditing showed that there was a predominance of infectious diseases like fever, cough, cold, followed by asthma problems and GIT infections in the surveyed area from March-July. There was significant number of asthmatic cases. The age groups of 11.00±6.25–50.00±9.75 years were found more prone to diseases. This is an alarming situation to be considered for health awareness since this is the most productive age group in the development of the nation. Economic hindrances, illiteracy or semi-literacy, reluctance about hygiene were major causes of infectious diseases noticeable mostly among the rural patients. Smoking habits were found strongly correlated with the incidence of asthma and were found mostly common amongst male population involved in the occupations of constructions (masons and painters), gardeners, security guards, peons, and clerical staff from the adjoining rural areas of Kharagpur. Some incidences of smoking related asthma were also observed amongst the educated urban class of Kharagpur region.

Most of the prescriptions were of seven-day duration. Drug utilization pattern indicated that, the most commonly used drug categories were antibiotics followed by anti histaminics, vitamins, analgesics, antipyretics, antihypertensives, expectorant-mucolytics, antitussives, antiamoebics and antiprotocozaal. Most commonly used antibiotic was amoxycillin. Nimesulide and ibuprofen were the most commonly used analgesics and aspirin and paracetamol were used as antipyretics. Amongst antacids H2- antagonists like ranitidine and famotidine were predominating along with aluminium and magnesium salts containing antacid suspensions like Gelusil MPS®. Cetirizine was most popular among anti-histaminics although corticosteroids (beclomethasone), β2-agonists (salbutamol, salmeterol and terbutaline), and methyl xanthenes (theophylline and etophylline) were used. Prescription auditing showed that among the anti-asthmatics’ salbutamol, beclomethasone, montelukast was mostly prescribed. Poly-pharmacy was widely prevalent especially in case of fever, cough, cold, asthma, GIT infections followed by diabetic incidences.
Fig. 1: Distribution of prescriptions according to the duration

Fig. 2: Distribution of prescriptions according to disease condition

Fig. 3: Distribution of prescriptions according to drug category
Fig. 4: Prevalence of poly-pharmacy amongst the audited prescriptions

Fig. 5: Reasons of self-medication in urban population

Fig. 6: Reasons of self medication in rural population
In self-medication practice urban population was much ahead of their rural counterpart. Easy availability of OTC drugs, wide advertisement by mass media publicity, access to internet and enhanced education levels were the major contributing factors of self-medication in urban areas. The survey found that pharmacists’ advices were preferred by rural patients for self-medication followed by influences from peer groups in contrast to the urban population. However in rural population, inability to pay physician fees, lack of RMPs, and disrupted communication for avail of drugs from clinics, non-availability of drugs in hospitals, gaps in health care infrastructure and failure of many primary health centers (PHCs) to provide minimum health needs prompted the rural patients to undergo self medication.

5. CONCLUSION

Prescription auditing is one of the scientific methods to assess and evaluate the rationality of the prescription. Current research via prescription auditing helped to form an idea about the drug utilization trend in the surveyed area during the two-year study period. The prescription based survey showed a predominance of infectious diseases in the month of March-July with increasing incidences of asthma. Hence physicians in this area whether attached to government hospitals or private practitioners should be encouraged to follow asthma guidelines while managing asthma patients and come forward for the successful implementation of interventional health programs like National Asthma Education Program in improving asthma knowledge, necessity of smoking cessation, generate mass awareness for improvement of personal hygiene, diet and lifestyle which may be beneficial as an initial step for protection against infectious diseases like GI-infections (Pandey et al., 2010).

Self-medication is an element of self care when it is related to nutrition, healthy lifestyle and hygienic practices but can have disastrous far reaching consequences when it comes to contraindications and serious adverse drug reactions (Chawla et al., 2013; Krishnaswamy and Kumar, 2005). Self care is obviously the primary source of any health care system (Krishnaswamy and Kumar, 2005). When patients are making decisions about the use of non-prescription drugs, the highly trained pharmacists could play a pivotal role in helping people make correct choices about self care, optimum selection and utilization of drugs. Pharmacists can provide drug information on possible side effects; direction and duration of use; contraindications and possible interactions (Sjokvist and Birkett, 2003; Sills et al., 2009; Chawla et al., 2013; Patel et al., 2012; Pisarik, 2010). Medicines used for self-medication must be of desired quality, efficacy and proven safety and is desirable to use in disease conditions that are self-recognizable or if used in case of chronic conditions it should be used following initial medical diagnosis (Pisarik, 2010; Abidi et al., 2012; Bhattacharya et al., 2012; Pandey et al., 2010; Jyoti et al., 2013).

It is highly recommended that there should be definitive therapeutic drug monitoring system for close monitoring of drug utilization pattern by the pharmacist in the outpatient departments (OPD) of the hospitals for the proper guidance of the patients. Government should enforce distinctions between prescription and non-prescription drugs simultaneously imposing strict sales policy for preventing the dispensing of prescription drugs without prescription to the self-medicator. Pharmaceutical industries while advertising and marketing non-prescription drugs should never make any false claim on efficacy, rather they should provide accurate information and exhibit fair balance between benefits and risks involved. In no cases companies for promotion of sales should encourage irresponsible self-medication.

Fig. 7: Distribution of drugs used for self-medication
Finally it can be concluded that such pharmacoepidemiological studies are essential to know about the drug utilization trend and thus improve the quality of public health care through rational usage of drugs. Boosting public health programmes and health management, monitoring of drug utilization pattern, development of evidence based essential drug list, targeted in-service training and public awareness are some of the strategies which can be adopted to ensure rational drug use (Krishnaswamy and Kumar, 2005).

The proper channelization and combination of pentagonal forces of physicians, patients, pharmacists, pharmaceutical industries and policies could make all necessary resources available to develop a healthy environment (Krishnaswamy and Kumar, 2005; Chawla et al., 2013).

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REFERENCES


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Full Length Research Paper

Synthesis, Spectral Correlations and Biological Evaluation of Some Aryl (E)-N-Benzylidene-3-nitrobenzenamines

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Abstract. Assessment of substituent effects in a series of aryl imines through spectral correlation has been studied since they have close pharmacological association with diverse pharmacological properties. A series of aryl imines have been synthesized from 3-Nitro aniline with various substituted benzaldehydes were refluxed for 4h with 20 mL of absolute ethanol. The purity of all imines has been checked using their physical constants and spectral data. The UV λmax(nm), infrared νC=N(cm⁻¹), NMR δ(ppm) of CH=N and C=N spectral data have been correlated with Hammett substituent constants and F and R parameters using single and multi-linear regression analysis. From the results of statistical analysis, the effect of substituents on the above spectral data has been studied. The single parameter correlation with few Hammett constants and F and R parameters gave satisfactory correlation coefficients whereas all multiple correlations gave satisfactory correlation coefficients with Resonance, Field and Swain-Lupton’s parameters. The antimicrobial activities of all imines have been studied using Bauer-Kirby method. Aryl imine compounds with 2-Cl, 4-Br and 2-OCH₃, substituents have shown good antibacterial activity against S.aureus and those with 3-NO₂ and 4-NO₂ substituents have shown good antifungal activity against T.viridi.

Key words: E-Aryl imines; UV, IR and NMR spectra; Substituent effects.

1. INTRODUCTION

The discovery and development of antibiotics are among the most powerful and successful achievements of modern science and technology for the control of infectious diseases. However, the increasing microbial resistance to antibiotics in use nowadays necessitates the search for new compounds with potential effects against pathogenic bacteria. The most spectacular advances in medicinal chemistry have been made when heterocyclic compounds played an important role in regulating biological activities. Benzylidene anilines belong to a class of compound called aldimines, which are the condensed products of aldehydes or ketones with primary amines and have azomethine group (CH=N) as the characteristics functional moiety. Interests in these compounds are largely due to their structural similarities with natural biological substances and relatively simple procedures of synthesis as well as synthetic flexibility that enable the design of suitable structural properties (Patai 2009; Jungreis et al., 1969). They are well known intermediate for the preparation of azetidinone (Bongini et al., 2000), thiazolidinone (Mulwad et al., 2002), formazone (Weber et al., 2005), ary lacetamide (Fukumura 2008), metal complexes (Singh 2007; Zhu et al., 2008; Zhu et al., 2009) and many other derivatives (Wang et al., 2008; Cheng et al., 2009).

An interesting application of Schiff bases is their use as an effective corrosion inhibitor which is based on their ability to spontaneously form a monolayer on the surface to be protected (Hosseini et al., 2008). Schiff bases have been found to posses more inhibitor efficiency than their constituent carbonyls and amines (Chitra et al., 2010). The Schiff bases constitute one of the most active classes of the compounds possessing diversified biological applications. The Schiff bases have been reported to possess higher degree of antitubercular (Solak et al., 2006), anticancer (Kuzmin et al., 2005), antibacterial (Shlyakhov et al., 1989), anti-inflammatory (Bawa et al., 2009), antifungal (Hothi et al., 2008). Several Schiff bases have been reported to possess remarkable antitumor (Kato, 1985), diuretic (Mishra et al., 1995), insecticidal (Zhu et al., 2000), anti-HIV (Sridhar et al., 2001) and antiparasitic (Forbes et al., 2003) activities. Therefore the authors have taken efforts for the synthesis of substituted benzylidene-3-nitroamines in condensation reaction. Also there is no information in the literature regarding the correlation study of the quantitative structure property relationship from UV, IR and NMR spectroscopic data with Hammett equation. The biological activities of these imine
derivatives have been studied using Bauer–Kirby (Bauer et al., 1966) method.

2. MATERIALS AND METHODS

2.1. General

All the chemicals involved in the present investigation, have been procured from Sigma-Aldrich and E-Merck chemical companies. Melting points of all the imines have been determined in open glass capillaries on SUNTEX melting point apparatus and are uncorrected. The UV spectra of all the imines, synthesized, have been recorded with ELICO-BL222 spectrophotometer λ_{max} (nm) in spectral grade methanol solvent. Infrared spectra (KBr, 4000-400 cm^{-1}) have been recorded on AVATAR-300 Fourier transform spectrophotometer. The NMR spectra were recorded in Bruker AV400 NMR spectrometer operating at 400 MHz has been utilized for recording \textsuperscript{1}H NMR spectra and 100 MHz for \textsuperscript{13}C spectra in CDCl\textsubscript{3} solvent using TMS as internal standard.

2.2. Preparation of Schiff base

Equimolar quantities of benzaldehyde (0.01mol) and 3-nitroaniline (0.01mol) were refluxed for 4h with 20 mL of absolute ethanol (Issa et al., 2008) and it is shown in (Scheme-1). After the completion of the reaction, as monitored by TLC, the mixture was cooled at room temperature. The resulting precipitate was filtered and washed with cold water. The product appeared as pale yellow solid. Then this was recrystallized using ethanol to obtain pale yellow glittering solid. The analytical and physical constants of these synthesized Schiff’s bases are presented in Table 1.

![Scheme 1: Synthesis of (E)-N-Benzylidene-3-nitrobenzenamines](image)

\[ X = H, 4-Br, 2-Cl, 4-Cl, 4-F, 4-CH_3, 2-OCH_3, 4-OCH_3, 3-NO_2 \]

Table 1: Physical constants and mass spectral data of substituted benzylidene-3-nitroanilines

<table>
<thead>
<tr>
<th>Entry</th>
<th>X</th>
<th>M. F</th>
<th>M. W.</th>
<th>m.p. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>C_{13}H_{14}Br_{2}O_{2}</td>
<td>236.23</td>
<td>101-102 <a href="32">74</a></td>
</tr>
<tr>
<td>2</td>
<td>4-Br</td>
<td>C_{13}H_{12}BrN_{2}O_{2}</td>
<td>305.13</td>
<td>108-109</td>
</tr>
<tr>
<td>3</td>
<td>2-Cl</td>
<td>C_{13}H_{12}ClN_{2}O_{2}</td>
<td>260.68</td>
<td>91-92 <a href="33">114-116</a></td>
</tr>
<tr>
<td>4</td>
<td>4-Cl</td>
<td>C_{13}H_{12}ClN_{2}O_{2}</td>
<td>260.68</td>
<td>120-121<a href="33">124-125 S</a></td>
</tr>
<tr>
<td>5</td>
<td>4-F</td>
<td>C_{13}H_{12}FN_{2}O_{2}</td>
<td>244.22</td>
<td>96-97</td>
</tr>
<tr>
<td>6</td>
<td>4-CH_3</td>
<td>C_{14}H_{14}H_2N_2O_3</td>
<td>240.26</td>
<td>112-113</td>
</tr>
<tr>
<td>7</td>
<td>2-OCH_3</td>
<td>C_{13}H_{12}H_2N_2O_3</td>
<td>256.26</td>
<td>73-74</td>
</tr>
<tr>
<td>8</td>
<td>4-OCH_3</td>
<td>C_{14}H_{14}H_2N_2O_3</td>
<td>256.26</td>
<td>104-105<a href="34">109</a></td>
</tr>
<tr>
<td>9</td>
<td>3-NO_2</td>
<td>C_{13}H_{12}H_2N_4C_4</td>
<td>377.40</td>
<td>141-142<a href="35">158</a></td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

3.1. Spectral linearity

In the present study the spectral linearity of synthesized imines has been studied by evaluating the substituent effects. The spectral data observed for the imines, UV \( \lambda_{\text{max}} \) (nm), infrared \( \nu \text{C}=\text{N} \), the proton chemical shifts \( \delta \text{ppm} \) of C-H and carbon chemical shifts of C=N are correlated with various substituent constants.

3.1.1. UV-Vis spectral study

The measured absorption maxima (\( \lambda_{\text{max}} \) nm) values of the synthesized imines have been recorded and
presented in Table-2. These data are correlated with Hammett substituent constants and F and R parameters using single and multi-linear regression analysis (Sakthinathan et al., 2012, Suresh et al., 2013, Sathiyanamoorthy et al., 2013, Jovanovic et al., 2002 and Drmanic et al., 2002). Hammett equation employed, for the correlation analysis, involving the absorption maxima is as shown below in equation (1).

\[ \lambda = \rho \sigma + \lambda_o \]  

(1)

Where \( \lambda_o \) is the frequency for the parent member of the series.

**Table 2:** The UV, IR and NMR spectroscopic data of substituted benzylidene-3-nitroanilines

<table>
<thead>
<tr>
<th>Entry</th>
<th>X</th>
<th>UV(\lambda_{max}) (nm)</th>
<th>(\nu_{IR}) (cm(^{-1}))</th>
<th>(\delta^1\text{H}) (ppm)</th>
<th>(\delta^{13}\text{C}) (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>300.89</td>
<td>1525.69</td>
<td>8.38</td>
<td>161.09</td>
</tr>
<tr>
<td>2</td>
<td>4-Br</td>
<td>332.50</td>
<td>1511.84</td>
<td>8.46</td>
<td>161.19</td>
</tr>
<tr>
<td>3</td>
<td>2-Cl</td>
<td>329.95</td>
<td>1525.84</td>
<td>8.37</td>
<td>159.25</td>
</tr>
<tr>
<td>4</td>
<td>4-Cl</td>
<td>337.50</td>
<td>1510.26</td>
<td>8.40</td>
<td>160.79</td>
</tr>
<tr>
<td>5</td>
<td>4-F</td>
<td>328.81</td>
<td>1512.19</td>
<td>8.41</td>
<td>161.03</td>
</tr>
<tr>
<td>6</td>
<td>4-CH(_3)</td>
<td>295.24</td>
<td>1525.69</td>
<td>8.38</td>
<td>160.73</td>
</tr>
<tr>
<td>7</td>
<td>2-OCH(_3)</td>
<td>357.50</td>
<td>1519.91</td>
<td>8.90</td>
<td>158.66</td>
</tr>
<tr>
<td>8</td>
<td>4-OCH(_3)</td>
<td>349.56</td>
<td>1517.98</td>
<td>8.70</td>
<td>161.90</td>
</tr>
<tr>
<td>9</td>
<td>3-NO(_2)</td>
<td>339.96</td>
<td>1519.91</td>
<td>8.95</td>
<td>159.65</td>
</tr>
</tbody>
</table>

The results of statistical analysis of these values with Hammett substituent constants are presented in Table 3. From Table 3, it is observed that the UV absorption maximum \(\lambda_{max}\) (nm) values have shown satisfactory correlation with Hammett substituent constants \(\sigma, \sigma^+, \sigma_I, \sigma_R, F \) and \( R \) parameters.

**Table 3:** Results of statistical analysis of UV \(\lambda_{max}\) (nm), \(\nu_{C=N}\) (cm\(^{-1}\)) IR, NMR \(\delta^1\text{H}\) (ppm) \(\text{CH} = \text{N}\) and \(\delta^{13}\text{C}\) (ppm) \(\text{C} = \text{N}\) of substituted benzylidene-3-nitroanilines with Hammett substituent constants \(\sigma, \sigma^+, \sigma_I, \sigma_R, F \) and \( R \) parameters

<table>
<thead>
<tr>
<th>Frequency Constants</th>
<th>(\lambda_{max}) (nm)</th>
<th>(\nu_{C=N}) (cm(^{-1}))</th>
<th>(\delta^1\text{H}) (ppm)</th>
<th>(\delta^{13}\text{C}) (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\lambda_{max})</td>
<td>(\sigma)</td>
<td>0.802</td>
<td>330.44</td>
<td>81.92</td>
</tr>
<tr>
<td></td>
<td>(\sigma^+)</td>
<td>0.705</td>
<td>330.38</td>
<td>81.79</td>
</tr>
<tr>
<td></td>
<td>(\sigma_I)</td>
<td>0.696</td>
<td>311.21</td>
<td>55.20</td>
</tr>
<tr>
<td>(\nu_{C=N})</td>
<td>(\sigma_R)</td>
<td>0.900</td>
<td>310.23</td>
<td>-44.56</td>
</tr>
<tr>
<td></td>
<td>(\sigma_F)</td>
<td>0.655</td>
<td>214.35</td>
<td>57.11</td>
</tr>
<tr>
<td></td>
<td>(\sigma_R)</td>
<td>0.885</td>
<td>220.34</td>
<td>-37.66</td>
</tr>
<tr>
<td>(\delta^1\text{H})</td>
<td>(\sigma_F)</td>
<td>0.923</td>
<td>1524.32</td>
<td>12.67</td>
</tr>
<tr>
<td>(\delta^{13}\text{C})</td>
<td>(\sigma_F)</td>
<td>0.835</td>
<td>1521.87</td>
<td>0.62</td>
</tr>
<tr>
<td>(\delta^1\text{H})</td>
<td>(\delta^{13}\text{C})</td>
<td>0.938</td>
<td>1524.92</td>
<td>4.37</td>
</tr>
<tr>
<td>(\delta^{13}\text{C})</td>
<td>(\delta^1\text{H})</td>
<td>0.894</td>
<td>1522.33</td>
<td>5.09</td>
</tr>
</tbody>
</table>

The remaining Hammett substituent constants namely \(\sigma, \sigma^+, \sigma_I, \sigma_R, F \) and \( R \) parameters have shown poor correlations. This is attributed to the weak polar, field and resonance effects of the substituents for predicting the reactivity on the UV absorption through resonance as per the conjugative structure as shown in Fig-1.

The multi regression analysis of these UV spectral data of all imines with inductive, resonance and Swain – Lupton’s (Swain et al., 1968) constants produce satisfactory correlations as shown in equations (2) and (3).

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**3. 1. 2. IR Spectral study**

The infrared νC=N stretching frequencies (cm⁻¹) of the synthesized imines have been recorded and presented in Table-2. These data are correlated (Sakthinathan et al., 2012, Suresh et al., 2013, Sathiyamoorthi et al., 2013, Jovanovic et al., 2002 and Drmanic et al., 2002) with Hammett substituent constants and Swain-Lupton’s parameters. In this correlation the structure parameter Hammett equation employed is as shown in equation (4).

$$\nu = \rho \sigma + \nu_o$$  \hspace{1cm} (4)

Where $\nu_o$ is the frequency for the parent member of the series.

The assigned νC=N stretching frequencies (cm⁻¹) are correlated with various Hammett substituent constants and F and R parameters through single and multi-regression analyses including Swain-Lupton’s (Swain et al., 1968) parameters. The results of statistical analysis of single parameter correlation are shown in Table 3. From Table 3, it is observed that the infrared stretching frequency νC=N(cm⁻¹) values have shown satisfactory correlation with Hammett substituent constant $\sigma_I(r = 0.923)$ and $F$ parameter ($r = 0.938$). The remaining Hammett substituent constants namely $\sigma$, $\sigma+$ and $\sigma_R$ and $R$ parameter have shown poor correlations. This is attributed to the weak polar, inductive, resonance and field effects of the substituents for predicting the reactivity on the stretching frequency through resonance as per the conjugative structure as shown in Fig-1. So, the authors think that it is worthwhile to seek the multi regression analysis which may produce a satisfactory correlation with Resonance, Field and Swain-Lupton’s (Swain et al., 1968) constants. This is shown in the following equations (5) and (6).

$$\nu_{C=N}(cm^{-1}) = 1526.352(\pm3.573) - 12.402(\pm4.132) \sigma_I + 8.216(\pm2.699) \sigma_R \hspace{1cm} (5)$$

$$\nu_{C=N}(cm^{-1}) = 1526.352(\pm3.278) - 12.571(\pm4.152) F - 6.943(\pm2.731)R \hspace{1cm} (6)$$

$$R = 0.962, n = 9, P > 95\%$$

$$R = 0.967, n = 9, P > 95\%$$
correlations with the imine proton chemical shifts, the authors think that, it is worthwhile to seek multiple correlations involving either \( \sigma_I \) and \( \sigma_R \) constants or

\[
\delta\text{CH}=\text{N}(\text{ppm}) = 8.501(\pm0.174) -0.259(\pm0.175) \sigma_I - 0.289(\pm0.0764) \sigma_R \ldots (8)
\]

\[
(R = 0.935, n = 9, P > 95\%)
\]

\[
\delta\text{CH}=\text{N}(\text{ppm}) = 8.573(\pm0.180) +0.104(\pm0.073) F - 0.166(\pm0.072) R \ldots (9)
\]

\[
(R = 0.922, n = 9, P > 95\%)
\]

3.1.4. \(^{13}\text{C} \) NMR spectra

In the present study, the chemical shifts (ppm) of imines \(^{13}\text{C}=\text{N}\) carbon, have been assigned and are presented in Table-2. Attempts have been made to correlate the \(^{13}\text{C}=\text{N}\) chemical shifts (ppm) with Hammett substituent constants, field and resonance parameters, with the help of single and multi-regression analyses to study the reactivity through the effect of substituents. The chemical shifts (ppm) observed for the \(^{13}\text{C}=\text{N}\) have been correlated with Hammett constants and the results of statistical analysis (Sakthinathan et al., 2012, Suresh et al., 2013, Sathiyamoorthi et al., 2013, Jovanovic et al., 2002 and Drmanic et al., 2002) are presented in Table-3. From Table-3, it is observed that the \(^{13}\text{C} \) chemical shift \( \delta\text{C}=\text{N}(\text{ppm}) \) values have shown satisfactory

\[
\delta\text{C}=\text{N}(\text{ppm}) = 160.869(\pm1.569) -2.240(\pm0.726) \sigma_I -3.962(\pm1.144) \sigma_R \ldots \ldots (10)
\]

\[
(R = 0.953, n = 9, P > 95\%)
\]

\[
\delta\text{C}=\text{N}(\text{ppm}) = 160.066(\pm1.006) +0.930(\pm0.054) F - 1.001(\pm0.072) R \ldots \ldots (11)
\]

\[
(R = 0.955, n = 9, P > 95\%)
\]

3.2. Anti-microbial activities

Aryl imines possess a wide range of biological activities these multi-prolonged activities are associated with different substituents and the unsaturation of C=\text{N} moiety in between the aryl rings. Hence, it is intended to examine their antimicrobial activities against their respective microbes-bacterial and fungal strains.

3.2.1. Antibacterial sensitivity assay

Antibacterial sensitivity assay has been performed by using disc diffusion (Bauer et al., 1996) technique. In each Petri plate about 0.5 ml of the test bacterial sample has been spread uniformly over the solidified Mueller Hinton agar using sterile glass spreader. Then the discs with 5mm diameter made up of Whatmann No.1 filter paper, impregnated with the solution of the compound have been placed on the medium using sterile forceps. The plates have been incubated for 24 hours at 37°C by keeping the plates upside down to prevent the collection of water droplets over the medium. After 24 hours, the plates have been visually examined and the diameter values of the zone of inhibition were measured. Triplicate results have been recorded by repeating the same procedure.

The antibacterial screening effect of synthesized imines is shown in Fig-2 (Plates 1-10). The antibacterial activities of all the synthesized imines have been studied against three gram positive pathogenic strains Micrococcus luteus, Bacillus substilis, Staphylococcus aureus and two gram negative strains Escherichia coli and Klebsiellaspecies. The disc diffusion technique was followed at a concentration of 250µg/mL with Ampicillin taken as the standard drug. The zone of inhibition is compared using Table-4 and the corresponding clustered column chart is shown in Fig-3. A good antibacterial activity has been possessed by all substituents on the microorganisms in general. The substituents H and 2-Cl have very good activity against Micrococcus luteus. The substituent 4-Cl has improved antibacterial activity against B.substilis. The substituents2-Cl, 4-Br and 2- OCH\(_3\) have very good activity against S.aureus.
Table 4: Antibacterial activity of substituted benzylidene-3-nitroanilines

<table>
<thead>
<tr>
<th>S.No</th>
<th>X</th>
<th>Gram positive bacteria</th>
<th>Gram negative bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>B.subtili</td>
<td>Micrococcus</td>
</tr>
<tr>
<td>1</td>
<td>H</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>4-Br</td>
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<td>8</td>
</tr>
<tr>
<td>3</td>
<td>2-Cl</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
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<td>4-Cl</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>4-F</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>4-CH₃</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>2-OCH₃</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>8</td>
<td>-</td>
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<tr>
<td>9</td>
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<td>?</td>
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<td>14</td>
</tr>
<tr>
<td>Control</td>
<td>DMSO</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

3.2.2. Antifungal sensitivity assay

Antifungal sensitivity assay has been performed using disc diffusion technique (Bauer et al., 1996). PDA medium was prepared and sterilized as above. It has been poured (ear bearing heating condition) in the Petri-plate which has been already filled with 1ml of the fungal species. The plates have been rotated clockwise and counter-clockwise for uniform spreading of the species. The discs have been impregnated with the test solution. The test solution has been prepared by dissolving 15mg of the imines in 1ml of DMSO solvent. The medium have been allowed to solidify and kept for 24 h. Then the plates have been visually examined and the diameter values of zone of inhibition have been measured. Triplicate results have been recorded by repeating the same procedure. The antifungal activities of substituted imines have been studied and are shown in Fig. 4 for Plates (1-4) and the zone of inhibition values of the effect is given in Table-5. The clustered column chart, shown in Fig-5. It reveals that the compounds with H, 2-Cl and 4-CH₃ substituents have moderate antifungal activity against A.niger. The compounds with substituents 3-NO₂and 4-NO₂ have good activity against T.viride.

Table 5: Antifungal activities of substituted benzylidene-3-nitroanilines

<table>
<thead>
<tr>
<th>Entry</th>
<th>X</th>
<th>Zone of Inhibition (mm)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>A.niger</td>
</tr>
<tr>
<td>1</td>
<td>H</td>
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<td>2</td>
<td>4-Br</td>
<td>-</td>
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<tr>
<td>3</td>
<td>2-Cl</td>
<td>8</td>
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<tr>
<td>4</td>
<td>4-Cl</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>4-F</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>4-CH₃</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>2-OCH₃</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>4-OCH₃</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>3-NO₂</td>
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<tr>
<td>Standard</td>
<td>Miconazole</td>
<td>14</td>
</tr>
<tr>
<td>Control</td>
<td>DMSO</td>
<td>---</td>
</tr>
</tbody>
</table>
Fig. 2: Antibacterial activities of Substituted (E)-N-benzylidene-3-nitro benzenamines - petri dishes
Some imines have been synthesized by condensation of amines and benzaldehydes. These imines have been characterized by their physical constants, spectral data. The UV, IR, NMR spectral data of these imines has been correlated with Hammett substituent constants, F and R parameters. From the results of statistical analyses the effects of substituent on the spectral data have been studied. The antimicrobial activities of all synthesized imines have been studied using Bauer-Kirby method.

4. CONCLUSION
ACKNOWLEDGEMENT

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Adsorption Behavior Investigation of Malachite Green Dye onto Animal Bone Meal; Kinetic and Isotherm Studies

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Abstract. Removal of Malachite green from aqueous media was achieved onto Animal bone meal as a new low cost adsorbent. The latter was characterized by Infra-Red and X-ray diffraction. The adsorption of Malachite green was occurred by studying the effects of adsorbent amount, dye concentration, contact time, pH media and temperature. The adsorption rate data were analyzed using the pseudo-first order and the pseudo-second order kinetics models to determine adsorption rate constants. Thermodynamic parameters were also evaluated for the dye-adsorbent system and revealed that the adsorption process is endothermic nature and spontaneous process under investigated temperatures. The results concluded that animal bone meal could be effectively employed as promising new low cost adsorbent for the removal textile dyes from aqueous solutions.

Keywords: Malachite green, Adsorption, Kinetics, Animal Bone Meal

1. INTRODUCTION

Dyes are one of the most important hazardous species found in textile industry produces in wastewater. Its presence in water bodies reduces light penetration, precluding the photosynthesis of aqueous flora (Boyer et al., 2010 and Al-Degs et al., 2008), besides of being aesthetically objectionable for drink water. Also, dyes can causes allergy, dermatitis, skin irritation and also provoke cancer and mutation in humans (De Lima et al., 2007 and Rosenkranz et al., 2007). The colour and the non-biodegradable nature of the spent dye baths cintitute serious environmental problems.

Many treatment methods have been investigated to remove dyes from wastewater. These methods can be classified as chemical coagulation/flocculation, ozonation, oxidation processes, chemical precipitation, ion exchange, reverse osmosis, ultra filtration and etc., for the removal of dyes from dye containing wastewater have serious restrictions such as high cost, formation of hazardous by-products or intensive energy requirements (Yazdanbakhsh et al., 2011 and Tabari et al., 2012). Therefore, the development of efficient, low cost and environmentally friendly technologies to reduce dye content in wastewater is extremely necessary. Among treatment technologies, adsorption is rapidly gaining prominence. Adsorption techniques for wastewater treatment have become more popular in recent years owing to their efficiency in the removal of pollutants which are stable for biological methods. Adsorption can produce high quality water while also being a process that is economically feasible (Choy et al., 1999).The physical characteristics of the adsorbents, such as surface area, porosity, size distribution, density and surface charge have high influence in the adsorption process. As a result, there has been a great interest in developing new adsorbent materials with diverse compositions, properties and functionalities. Activated carbon is the most widely used adsorbent for dye removal, but it is too expensive (Malik et al., 2003), consequently, numerous low cost alternative adsorbents have been proposed including: Chemically modified sugarcane bagasse lignin (Da Silva et al., 2011), Pistachio hull waste (Moussavi et al., 2011), Coffee husk-based activated carbon (Ahmad et al., 2011), Pine cone (Mahmoodi et al., 2011), Rice husk (Safa et al., 2011), Synthetic calcium phosphates (El Boujaady et al., 2011), Natural untreated clay (Errais et al., 2011), Pillared clays (Gil et al., 2011), Swelling clays (Li et al., 2011).

In the purpose of this work, adsorption of Malachite green dye onto Animal Bone Meal (ABM) has been investigated. The effect adsorbent amount and initial dye concentration has been studied. Kinetic experiments have been also conducted to determine the rate of Malachite green adsorption onto ABM. The obtained experimental data were analyzed using isotherm models namely, Langmuir and Freundlich.

2. MATERIALS AND METHODS

2.1. Preparation of adsorbent

Animal bones were collected from nearby butcher shops. All of the attached meat and fat were removed
and cleaned from the bones. The bones were then washed several times with tap water and left in open air for several days to get rid of odors. Later, they were transferred to the oven at 80 °C for drying. The dried bones were crushed and milled into different particle sizes in the range 45-200 µm then calcined for 2 h at 800 °C. The residue was washed with water and was used after drying for 24 h at 80 °C. The residue was washed with water and was dried overnight at 100 °C in a conventional drying oven, and then calcined at a heating rate of 2 °C/min to 400 °C and kept at this temperature for 4 h.

2.2. Adsorbate

Malachite green is the cationic dye, which was supplied from Fluka and was used without further purification. The chemical structure of this dye is shown in Figure 1. Dye solutions were prepared by dissolving requisite quantity of Malachite green in distilled water. The final prepared volume was 500 mL. Adsorption studies for the evaluation of ABM adsorbent for the removal of Malachite green dye from aqueous solutions were carried out in triplicate using a batch contact adsorption method.

![Figure 1: Chemical structure of Malachite green](image)

2.3. Instrumentation

Identification of ABM was carried out by X-ray diffractometer (Philips X’Pert PRO XRD). The measurements were obtained with a Rigaku D/MAX RB XRD using Cu Kα radiation (λ = 1.5418 Å and θ = 10-60°) at room temperature. The FTIR transmission spectra in the region 400-4000 cm⁻¹ were recorded for sample using Buck 500 spectrometer by KBr pellet technique. The specific surface area (SSA) of the ABM was calculated using the BET method from the nitrogen adsorption isotherms obtained at 77 K on samples out gassed at 250 °C with the use of a Micromeritics Accusorb 2100E apparatus. A Shimadzu UV-Vis spectrophotometer was used for determination of dye concentration at λ_max = 621 nm. The amount of adsorbed dye was calculated using the following expression:

\[
q_t = \frac{(C_0 - C_t)}{w} V \times 100
\]

(2)

Where \( q_t \) (mg/g) is the amount of Malachite green adsorbed at contact time \( t \) (min), \( C_0 \) (mol/L) is the initial dye concentration, \( C_t \) (mol/L) is the dye concentration at time \( t \) and \( w \) (g) is the ABM amount in the solution.

2.4. Adsorption procedure

The Adsorption experiments were carried out in batch. Preliminary experiments demonstrated that the equilibrium was established in 60 min. A 40 mg sample of ABM was mixed with 100 mL dye solution of 20 mg/L in batch. Samples of 5 mL of mixture were withdrawn from the batch at predetermined time intervals and the supernatant was centrifuged for 15 min at 3600 rpm. All dye solutions prepared were filtered by Millipore membrane type 0.45 µm HA, and the concentrations of dye were determined from its UV-Vis absorbance characteristic with the calibration method. A linear correlation was established between the dye concentration and the absorbance at \( \lambda_{\text{max}} = 621 \) nm, in the dye concentration range 0 – 30 mg/L with a correlation coefficient \( R^2 = 0.99 \). The adsorption capacity of Malachite green was calculated as follows:

\[
q_t = \frac{(C_0 - C_t)}{w} V
\]

(2)

Where \( q_t \) (mg/g) is the amount of Malachite green adsorbed at contact time \( t \) (min), \( C_0 \) (mol/L) is the initial dye concentration, \( C_t \) (mol/L) is the dye concentration at time \( t \) and \( w \) (g) is the ABM amount in the solution.

The effects of varying the ABM amount on dye adsorption were carried out by adding 10, 20, 40, 50 and 60 mg samples of ABM to 100 mL solution of Malachite green aqueous solution 20 mg/L as initial concentration. The effect of the initial dye concentration was investigated as follows: 40 mg sample of ABM was added to 100 mL solution of Malachite green with initial concentrations varying from 5 to 20 mg/L.
3. RESULTS AND DESCUSIONS

3.1. Characterization of ABM adsorbent

In order to investigate the surface characteristic of ABM, elemental analysis, IR and X-Ray diffraction spectrums were studied. Elemental analysis of ABM shows a high yield of Ca (49.62%) and P (42.36%) with a Ca/P ratio of 1.55. Small amounts of Si (3.88%), Mg (1.32%), Na (0.77%), Al (0.35%), Fe (0.24%), Cl (0.24%), S (0.11%), K (0.07%), Sr (0.03%), Cu (0.03%) and Zn (0.02%) are found. The IR absorption spectrum of ABM in Figure 2 shows bands characteristics of hydroxyapatite and more particularly a carbonated fluorapatite type B. We note the bands located between 1455 and 1430 cm⁻¹. These wave numbers are comparable with those of carbonated fluorapatites type B prepared according to the procedure used by Bonel (Bonel, 1972). Moreover, the IR shows independently of the bands of phosphates, bands located between 780 and 800 cm⁻¹ which could appear from the vibration of silicates groups.

![Fig. 2: IR spectrum of ABM](image)

The X-ray diffraction analysis confirms the presence of hydroxyapatite as shown in Figure 3. The specific surface area of ABM was determined by BET method from adsorption-desorption isotherm of nitrogen at its liquid temperature (77 K) and was found to be $S_p = 85 \text{ m}^2/\text{g}$. We have already used this support as catalyst for organic compounds synthesis (Riadi et al., 2011, 2010; Mamouni et al., 2010).

![Fig. 3: XRD pattern of ABM](image)
3.2. Effect of ABM adsorbent amount onto dye removal

Equilibrium experiments were carried out by contacting different amounts of ABM with 100 mL of Malachite green dye solution (20 mg/L). The agitation was made for 24h, which was found to be sufficient time to achieve equilibrium. The removal percent of Malachite green dye was increased with increasing adsorbent dosage. A maximum of 92.4 % removal of the dye was observed by 20 mg of ABM as shown in Figure 4.

It was observed that the uptake of the dye increased by the amount of ABM added and that the maximum dye removal was achieved within the amount of 40 mg. This implied that the number of adsorption sites increased as adsorbent mass enhances as shown in Figure 4. This isotherm belongs to type L of the Giles et al. classification (Giles et al., 1960), which indicates that, as more sites in the substrate are filled, it becomes increasingly difficult for the solute molecules to find an available vacant site. This could be either because of monolayer adsorption of solute molecules on a surface containing a finite number of identical sites and there is no strong competition from the solvent.

![Figure 4: Effect of adsorbent amount of ABM on Malachite green removal from 20 mg/L dye solution at 25°C.](image)

3.3. Effect of contact time of ABM and Malachite green dye concentration

The dye adsorption behavior onto ABM was studied by the variation of the equilibrium time in the range of 0 – 60 min. The adsorption capacity of the dye as a function of contact time plotted in Figure 5. The initial Malachite green concentrations used are 5, 10, 15 and 20 mg/L. This figure shows the effect of initial Malachite green concentration on the adsorption rate of the dye at 25°C. An increase in initial dye concentration leads to an increase in the adsorption capacity. As the initial dye concentration increases from 5 to 20 mg/L, the adsorption capacity of Malachite green onto ABM changes from 48.32 to 65.76 mg/g. Thus, this indicates that the total amount of dye uptake was found to occur in the first rapid stage. The higher adsorption rate at the initial period may be due to an increased number of vacant sites available at the initial stage, which is because of the existed increase in the concentration gradients between adsorbate in solution and adsorbate on the adsorbent surface. As time proceeds, the dye concentration is reduced to the accumulation of dye particles in the vacant sites, leading to a decrease in the adsorption rate at later stages. The obtained curves were single, smooth and continuous, indicating monolayer coverage of dye on the surface of adsorbent.
3.4. Kinetic studies

The kinetic models of pseudo-first order model, pseudo-second order were used to examine the adsorption mechanism. Pseudo-first order reaction model is described as follows (Lagergren et al., 1898):

\[
\frac{dq_t}{dt} = k_1(q_e - q_t)
\]  

(3)

Where \(q_e\) and \(k_1\) are the amount of dye adsorbed at equilibrium (mg/g) and the equilibrium rate constant of pseudo-first order kinetics (mn\(^{-1}\)), respectively. After integration by applying conditions, \(q_t = 0\) at \(t = 0\) and \(q_t = q_e\) at \(t = t\), then equation (2) becomes:

\[
\log(q_e - q_t) = \log q_e - \frac{k_1}{2.303}t
\]  

(4)

The rate constant \(k_1\) and \(q_e\) were obtained from the slope and intercept of the linear plots of \(\log (q_e - q_t)\) against \(t\), respectively. Pseudo-first order and pseudo-second order are the two kinetic models that were tested to explain the experimental data found. The agreement between experimental data and model calculated values is expressed by the correlation coefficient \(R^2\). The results are presented in Table 1. Kinetic adsorption of Malachite green onto ABM occurs with pseudo-second order model. In this fact, the higher values of \((R^2 > 0.99)\) and the good agreement between the experimental and calculated equilibrium describes correctly the adsorption kinetics. So, the lower values of \(R^2\) and the difference of experimental and calculated equilibrium with pseudo-first order model shows that the pseudo-first order model failed to describe the adsorption kinetics.

\[
\frac{dq_t}{dt} = k_2(q_e - q_t)^2
\]  

(5)

Where \(k_2\) is the equilibrium rate constant of pseudo-second order (g/mg.mn). On integrating the equation (4), equation (5) is obtained:

\[
\frac{t}{q_t} = \frac{1}{k_2q_e^2} + \frac{1}{k_2q_e}
\]  

(6)

The rate constant \(k_2\) and \(q_e\) were obtained from the slope and intercept of the linear plots of \(t/q_t\) against \(t\), respectively.

<table>
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<th>[Dye] (mg/L)</th>
<th>(q_e) exp (mg/g)</th>
<th>Pseudo-first order kinetic</th>
<th>Pseudo-second order kinetic</th>
<th>(R^2)</th>
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<th>(k_1) (g/mg.min)</th>
<th>(k_2) (g/mg.min)</th>
<th>(R^2)</th>
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<tr>
<td>5</td>
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<tr>
<td>20</td>
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<td>0.998</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Kinetic models parameters for adsorption of Malachite green onto ABM

Fig. 5: Effect of contact time and dye concentration on the adsorption amount of Malachite green by 20 mg of ABM at 25°C
3.4. Adsorption isotherms studies

Isotherms correlate the equilibrium data with different mathematical models to describe the behavior of the adsorption process; an optimized design of adsorption system provides valuable information. Accordingly, we evaluated the fitness of the equilibrium data obtained from the experiments with the Langmuir and Freundlich models. The best fitted model was selected based on the determination of correlation coefficient \( R^2 \). A mathematical expression of Langmuir model can be written as (Langmuir, 1918):

\[
q_e = \frac{Q_0 K_L C_e}{1 + K_L C_0}
\]

where \( q_e \) (mg/g) is the adsorbed amount at equilibrium, \( C_e \) is the equilibrium concentration of the adsorbate (mg/L), \( K_L \) is Langmuir equilibrium constant (L/mg) and \( Q_0 \) the maximum adsorption capacity (mg/g). The linear form of Langmuir equation is:

\[
\frac{C_e}{q_e} = \frac{1}{K_L Q_0} + \frac{C_e}{Q_0}
\]

The essential characteristic of Langmuir isotherm can be expressed by the dimensionless constant called equilibrium parameter, \( R_L \), defined by:

\[
R_L = \frac{1}{1 + K_L C_0}
\]

where \( C_0 \) is the initial dye concentration (mg/L). \( R_L \) values indicate the type of isotherm to be irreversible (\( R_L = 0 \)), favorable (\( 0 < R_L < 1 \)) and unfavorable (\( R_L > 1 \)) (Mahmoodi et al., 2008).

The Freundlich isotherm endorses the heterogeneity of the surface and assumes that the adsorption occurs at sites with different energy of adsorption. The energy of adsorption varies as a function of the surface coverage (Freundlich 1906). A mathematical expression of Freundlich isotherm was as follows:

\[
q_e = K_F C_e^{1/n}
\]

Where \( K_F \) (L/mg) is Freundlich constant and \( n \) is the heterogeneity factor. The \( K_F \) value is related to the adsorption capacity; while the \( 1/n \) value is related to the adsorption intensity. \( 1/n \) values indicate the type of isotherm to be irreversible (\( 1/n = 0 \)), favorable (\( 0 < 1/n < 1 \)) and unfavorable (\( 1/n > 1 \)) (Mahmoodi et al., 2008).

Eq. (9) can be rearranged to the following linear form:

\[
\log q_e = \log K_F + \frac{1}{n} \log C_e
\]

For this study, we used a sample of 40 mg of ABM which was added to 100 mL of dye solution at 20 mg/L. The data from the isotherm evaluation is summarized in Table 2. The correlation coefficient \( R^2 \) of the Langmuir isotherm model for all tested temperatures was higher than the Freundlich model, showing that the experimental equilibrium data was better explained by the Langmuir model. This finding supports the assumption that Malachite green is adsorbed as a homogeneous monolayer onto ABM particles sites.

<table>
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<tr>
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<th>35</th>
<th>45</th>
<th>55</th>
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<td>0.27</td>
<td>0.33</td>
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<td>( K_L )</td>
<td></td>
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<td>62.31</td>
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<td>64.54</td>
</tr>
<tr>
<td>( q_{\text{max}} )</td>
<td></td>
<td>0.08</td>
<td>0.07</td>
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</tr>
<tr>
<td>( R_L )</td>
<td></td>
<td>0.999</td>
<td>0.998</td>
<td>0.999</td>
<td>0.998</td>
</tr>
<tr>
<td>( R^2 )</td>
<td></td>
<td>0.899</td>
<td>0.897</td>
<td>0.914</td>
<td>0.889</td>
</tr>
<tr>
<td>Freundlich</td>
<td></td>
<td>19.36</td>
<td>20.44</td>
<td>23.78</td>
<td>25.76</td>
</tr>
<tr>
<td>( K_F )</td>
<td></td>
<td>3.31</td>
<td>3.38</td>
<td>3.73</td>
<td>3.90</td>
</tr>
<tr>
<td>( n )</td>
<td></td>
<td>0.899</td>
<td>0.897</td>
<td>0.914</td>
<td>0.889</td>
</tr>
</tbody>
</table>
4. CONCLUSION

The results indicated that ABM is a promising new low cost adsorbent for removal of Malachite green from aqueous solutions. The kinetics studies of dyes on ABM indicated that the adsorption kinetics of dye on ABM followed the pseudo-second order at different dye concentration values. The equilibrium data have been analyzed. The results showed that the Malachite green followed Langmuir isotherm model.

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Full Length Research Paper

Survey of Fishing Gear and Status of Fishers in Igbedi Creek, Nigeria Delta, Nigeria

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Abstract. A survey of fishing gear in Igbedi Creek, Niger Delta Area was carried out for six months from September 2012 to February 2013 to assess the types of fishing gear mostly used by fishers in this Creek. Five communities namely: Igbedi, Agorobene, Ogobiri, Toru-Ebene and Otuam were selected for the sampling framework. A total of 200 questionnaires were given out, 40 to each community. A two stage random sampling technique was adopted in the selection of fishers. Data collected was analyzed by using simple descriptive statistics, frequency and percentages. The greatest proportion (34.00%) of the fishers interviewed were within the age bracket of 30-39 years while 5.50% were within the non-active age (50 and above). Female fishers accounted for 61.00% while the males were 39.00%. Majority of the fishers (57.50%) were Ijaws and married fishers recorded the highest percentage (52.50%). Three types of fishing gears, hook and line, trap and net were used by the fishers. Net had the highest frequency (46.00%) while hook and line had the lowest percentage (7.50%). Most of the fishers (56.00%) generated about N2,500 to N3,000 as daily income while 17.50% realized more than N1,500 as daily income. Challenges affecting successful fishing operations include lack of fund to purchase fishing inputs, difficulty in accessing loans amongst others and proffered solutions were provision of fishing inputs at subsidized rate, provision of loans to fishers, provision of adequate extension services and others.

Key words: Survey, fishing gear, fishers, socio-economic, constraints, Igbedi Creek

1. INTRODUCTION

Fishing gears are the tool or implement or equipment used in capturing fish from any water body such as traps, hooks and lines, gill nets, trawls, seine nets, lift nets, clap nets, spears, cast nets, entangling nets, drift nets etc (Nuhu and Yaro, 2005; Tagago et al., 2011; Davies and Kwen, 2012). Due to different habits and habitats of the arrays of fish species in a particular water body, different gears are also being used for capturing fish (Tagago et al., 2011). Seasonal changes in species diversity and abundance have given ways to the invention of different fishing gear annually (Bankole et al., 2003). According to Du feu et al. (1997) different fishing gears were used by different fishers depending on the season of the year. Recently, based on advances of technology, it has led to the improvement of the types of fishing gears used by the artisanal fishers in most water bodies (Reed et al., 1967). Fishing gears used could be due to the peculiarity of the physical characteristics of the water body and availability of different types and size of fish species.

This study therefore aimed at identifying the types of fishing gears being used by the fishers and determined the daily catch and income generated by the fishers in the Creek. Also, it determined the challenges encountered by them, proffered solutions to the challenges in the Creek and likewise made recommendations from the findings of this study.

2. MATERIALS AND METHODS

2.1. STUDY AREA

Igbedi Creek is a distributary of the Nun River and also a tributary of River Niger. It is located geographically between longitudes 6° 03’E and 6° 20’E and Latitudes 4° 40’N and 5° 20’N. The Creek measures approximately 67 km in length from Agudama in Ekpetaama clan to Otuam. Some communities found along the banks of the Creek are Igbedi, Agorobene, Ogobiri, Toru-Ebene Amassoma and Otuam (Fig. 1).

2.2. DATA COLLECTON AND SAMPLING TECHNIQUES

Structured questionnaires were given out to fishers in Igbedi Creek, Wilberforce Island, Bayelsa State, Nigeria between September 2012 and February 2013.
A two stage random sampling technique was adopted in selecting the fishers along the banks of the Creek for six months. Five major communities namely: Igbedi, Agorobene, Ogobiri, Toru-Ebene and Otuan were selected to form the sampling frame work. Simple random sampling technique was adopted to draw 40 fishers (respondents) within each community. A total sample of 200 fishers was interviewed by using structured interview schedules and direct interview. Some of the information the questionnaires covered include socio-economic characteristics, types of fishing gear in use, daily catch and income and challenges encountered by the fishers in the Creek.

2.3. DATA ANALYSES

Data collected were collated and analyzed using simple descriptive statistics, frequency and percentages to describe the data collected on socio-economic characteristics of fishers, types of fishing gear used, daily catch and income and challenges encountered by fishers.

3. RESULTS

Data on the socio-economic characteristics of the respondents are presented in Table 1. Majority of the respondents (34.00%) fell within the agile and economically active age brackets of 30-39 years, while those who were above 50 years of age accounted for 5.50%. The females (61.00%) dominated in the fishing activities such as trap fishery, providing nets and crafts, while 39.00% of the respondents were males. On the marital status of the respondents, majority of them (52.50%) were married, 31.50% were single while 16.00% were divorced.

In a similar vein, data on the educational qualification shown that, more than half 47.50% of the respondents had primary education, 24.50% had no formal education, 19.00% had secondary education while 9.00% had tertiary education (Fig.2). Majority of the respondents (72.00%) engaged in full-time fishing while 27.50% engaged in part-time fishing (Fig. 3). The study showed that 72.00% of the respondents had 11-20 years fishing experience, 23.00% had over 20 years experience while 5.00% had 1-10 years experience (Table 1).

The results also revealed that more than half of the respondents (57.50%) were Ijaws followed by Hausa (28.50%), Igbo’s (5.50%) and others viz. Urhobos and Isoko etc, (8.50%) (Fig.4). Most of the respondents were engaged in fishing as dual purpose with 50.00% involved in both commercial and subsistence levels; 30.00% at commercial level and 20.00% at subsistence level (Fig. 5). Eighty-six percent (86.00%) of the respondents did not belong to any fish farming association while only 14.00% of them belonged to fish farming association (Table 1).

Table 2 shows the types of fishing gear used by the respondents in the Creek. Forty-six percent (46.00%) of the fishers used more of nets which comprised of gillnets, cast nets, seine nets and dragnet, 28.50% used traps, 7.50% hook and lines while 18.00% combined all the gear in their operations.

Table 3 reveals the daily catch and income generated by the fishers. Majority of the fishers (35.75%) caught fish between 2-3 Kg per day, followed by 4 Kg (13.00%), 5 Kg (10.00%) and 1 Kg (5.00%).
### Table 1: Socio-economic characteristics of the fishers in Igbedi Creek

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>10-19</td>
<td>40</td>
<td>20.00</td>
</tr>
<tr>
<td></td>
<td>20-29</td>
<td>50</td>
<td>25.00</td>
</tr>
<tr>
<td></td>
<td>30-39</td>
<td>68</td>
<td>34.00</td>
</tr>
<tr>
<td></td>
<td>40-49</td>
<td>31</td>
<td>15.50</td>
</tr>
<tr>
<td></td>
<td>50 and Above</td>
<td>11</td>
<td>5.50</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>78</td>
<td>39.00</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>122</td>
<td>61.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
<tr>
<td>Marital status</td>
<td>Married</td>
<td>105</td>
<td>52.50</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>63</td>
<td>31.50</td>
</tr>
<tr>
<td></td>
<td>Divorced</td>
<td>32</td>
<td>16.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
<tr>
<td>Fishing Experience</td>
<td>1-10</td>
<td>10</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>144</td>
<td>72.00</td>
</tr>
<tr>
<td></td>
<td>Above 20</td>
<td>46</td>
<td>23.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
<tr>
<td>Fish Farming Association</td>
<td>Belong to association</td>
<td>28</td>
<td>14.00</td>
</tr>
<tr>
<td></td>
<td>Not belong to association</td>
<td>172</td>
<td>86.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

Source: Field Survey, 2012

Fifty-six percent (56.00%) of the fishers earned between N2,500 and N3,000 per day from their sales, 17.50% realized N1,500 to N2,000, 12.00% earned N3,500 to N4,000, 9.00% N500 to N1,000 while only 5.00% of the fishers realized over N4,000 per day.

Table 4 presents the challenges encountered by the fishers and proffered solutions in Igbedi Creek. It revealed the challenges according to percentages in the decreasing order, where lack of fund to purchase fishing input (21.00%) constituted the major challenge of the fishers in the Creek, followed by difficulty in accessing loans (11.50%), poor extension services (11.50%), unorganized market (10.00%), flooding (8.50%), lack of good storage facility (8.50%), lack of social amenities (7.00%), poor road network (6.50%), invasion of aquatic weeds (6.00%), pollution (5.50%) and lastly poor catch (5.00%).
Table 2: Types of fishing gear used in Igbedi Creek

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gear</td>
<td>Hook and line</td>
<td>15</td>
<td>7.50</td>
</tr>
<tr>
<td></td>
<td>Trap</td>
<td>57</td>
<td>28.50</td>
</tr>
<tr>
<td></td>
<td>Net</td>
<td>92</td>
<td>46.00</td>
</tr>
<tr>
<td></td>
<td>All of the above</td>
<td>36</td>
<td>18.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
</tbody>
</table>

The suggested solutions to the challenges include provision of fishing inputs at subsidized rate (33.00%), provision of loans to fishers (19.00%), provision of adequate extension services (16.00%), provision of good marketing structures (15.00%), provision of social amenities (10.50%) and provision of good road network (6.00%).

4. DISCUSSION

The most economically agile and active age involved in fishing activities in this study fell within the age group of 30 to 39 years, which means that they were more of youths. This is in agreement with the reports of Agbelege et al. (2009), Agbontale (2009), Tagogo et al. (2011), Olaoye et al. (2011), Sanni et al. (2011), Adeyemo (2011) and Davies and Kwen (2013) who also reported that fishing activities are mostly done by people within the age range of 30 to 40 years. This distribution might probably be due to the fact that younger people are more enthusiastic in trying new practices in fisheries or fishing operations, mentally alert and have greater flexibility in accepting new ideas in fishing gear development techniques and also do their own business without any problem that affects old age. The high number of females dominating the fishing operations corresponded with that of Lahia et al. (2000), Olaoye et al. (2011) and Adeyemo (2011) that 45 to 65 percent of women actively participated in fishing activities in most parts of Nigeria. This could be attributed to these factors such as women presently participate more in both farming and fishing activities, they (females) are the food planners who specialize in dictating the diet of a particular family as they are the determinants of the nutritional level of a family and again, there is no

**Table 3: Daily catch and income generated by fishers in Igbedi Creek.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily catch (Kg)</td>
<td>1</td>
<td>10</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>97</td>
<td>48.50</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>46</td>
<td>23.00</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>26</td>
<td>13.00</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>21</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
<tr>
<td>Income per day (N)</td>
<td>500-1000</td>
<td>18</td>
<td>9.00</td>
</tr>
<tr>
<td></td>
<td>1500-2000</td>
<td>35</td>
<td>17.50</td>
</tr>
<tr>
<td></td>
<td>2500-3000</td>
<td>112</td>
<td>56.00</td>
</tr>
<tr>
<td></td>
<td>3500-4000</td>
<td>24</td>
<td>12.00</td>
</tr>
<tr>
<td></td>
<td>Above 4000</td>
<td>11</td>
<td>5.50</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
</tbody>
</table>

cultural belief restraining or disallowing women from participating in active fishing activities in the area (Niger Delta) as in other parts of Nigeria. The observed high number of married fishers in the creek is similar to that of Olaoye et al. (2011) reported that the artisanal sector is constituted majorly by married people fishers. The possible reason might be linked to the fact that married people have more pressing demands and problems at hand to solve than the unmarried (singles) and those that are divorced. More than half of the fishers had primary education and two third with no formal education is an indication that majority of fishers in Igbedi Creek had completed primary education. This will go long way to enhance extension services and new techniques with less difficulty since they have formal knowledge. Most of the fishers engaged in full-time fishing and few in part-time fishing. The above findings support the observation made by Smith (1979) who reported that fishing operation is being supplemented by those taking fish farming as part-time. Majority of the fishers in the Creek had 11 to 12 years fishing experience. This indicates that most fishers in the Creek are experienced, but only few are well experienced.

Table 4: Challenges encountered by fishers and proffered solutions in Igbedi Creek.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge</td>
<td>Lack of fund to purchase fishing inputs</td>
<td>42</td>
<td>21.00</td>
</tr>
<tr>
<td></td>
<td>Difficulty in accessing loans</td>
<td>23</td>
<td>11.50</td>
</tr>
<tr>
<td></td>
<td>Poor extension services</td>
<td>22</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>Unorganized markets</td>
<td>20</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td>Flooding</td>
<td>17</td>
<td>8.50</td>
</tr>
<tr>
<td></td>
<td>Lack of good storage facilities</td>
<td>16</td>
<td>8.00</td>
</tr>
<tr>
<td></td>
<td>Lack of social amenities</td>
<td>14</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td>Poor road network</td>
<td>13</td>
<td>6.50</td>
</tr>
<tr>
<td></td>
<td>Invasion of aquatic weeds</td>
<td>12</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Pollution</td>
<td>11</td>
<td>5.50</td>
</tr>
<tr>
<td></td>
<td>Poor catch</td>
<td>10</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
<tr>
<td>Proffered solutions</td>
<td>Provision of fishing inputs at Subsidized rate</td>
<td>66</td>
<td>33.00</td>
</tr>
<tr>
<td></td>
<td>Provision of loans to fishers</td>
<td>38</td>
<td>19.00</td>
</tr>
<tr>
<td></td>
<td>Provision of adequate extension services</td>
<td>33</td>
<td>16.50</td>
</tr>
<tr>
<td></td>
<td>Provision of good markets</td>
<td>30</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td>Provision of social amenities i.e health care, pipe born water, electricity etc</td>
<td>21</td>
<td>10.50</td>
</tr>
<tr>
<td></td>
<td>Provision of good road networks</td>
<td>12</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>200</td>
<td>100.00</td>
</tr>
</tbody>
</table>


Fishing is a business that is very lucrative which sustains life through job creation. The high number of Ijaw fishers in this creek is an indication that the Ijaw ethnic group dominated the fishing operations in the creek. This is because they are the major and only ethnic group occupying the banks of Igbedi Creek. This also corresponded with the report of Hoakonsen (1990) that African artisanal fishers predominantly belongs to a handful of ethnic groups such as Adam, Wolof, Lebou, Ewe, Nyominka, Ilae and Ijaws from Nigeria, Fentegal of Senegal, Ghana and Mali: these different ethnic groups constitute about half a million fishers in West African and operate on subsistence level. The observed fishing gears in the Creek were in consonance with those reported by Moses (1992), Daddy (2000) and Davies and Kwen (2013) that the gears adopted in artisanal fishery are majorly traditional. However, nets are the commonest fishing gears that have been adopted in the Creek.

The fishers in the Creek generated estimated high income and affirmed without reservation to remain in fishing business if granted access to government loan. According to Agbontale (2009), income of fishers to a great extent determines their ability to purchase improved fishing gears, improved fish processing equipment etc. The challenges encountered by fishers in Igbedi Creek is in agreement with the findings of Arowolo and Awotunde (2004), Ahmed et al. (2006), Ahmed and Eyo (2009), Agbontale (2009), Tagago et al. (2011) and Davies and Kwen (2013). However, lack of fund to purchase fishing inputs was ranked first or more challenging. The observed proffered solutions are similar to those reported by Tagago et al. (2011) and Davies and Kwen (2013). This might imply that these are the major challenges encountered by artisanal fishers in most parts of Nigeria.

5. CONCLUSION

In conclusion, the study has shown that there are three major types of fishing gear being used in Igbedi Creek such as hook and line, trap and net. The most common fishing gear being used is the net which comprises gillnets, drift nets, seine nets and cast nets. Majority of
the fishers’ age range was within the agile economically active range, which favoured fish farming or fishing development. The source of fund for majority of the fishers was personal investment and this is militating against the output of fishers in Igbedi Creek.

RECOMMENDATION
The following recommendations were made for the improvement and promotion of fishing activities and the standard of living of fishers in the Creek.

1. The government should provide loans to fishers either in cash or in kind, because this will enable them (fishers) to obtain more and new fishing gears and as well increase their catch and income generation.

2. Subsidy or reducing import taxes on fishing inputs such as fishing nets and accessories should be reinstated by the Federal Government of Nigeria.

3. Government should provide basic social amenities such as health care centre, road, pipe borne water, electricity etc.

4. Fishers should be encouraged to embark on alternative income generating activities through financial support and extension services in order to alleviate their poverty level.

ACKNOWLEDGEMENT
The authors are grateful to Mr. Kwen Womotimi and Dr. Erepa Young and all the field enumerators for their excellent job of data collection. The fishers around Igbedi Creek are equally acknowledged for their co-operation during the period of data collection.

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Full Length Research Paper

Application of Active Vibration Control for Earthquake Protection of Multi-Structural Buildings

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Abstract. Investigating the effectiveness of LQG output-feedback active control for seismic alleviation of multi-structural buildings is the main purpose of this study. A general model of a shear-frame multi-structure as a lumped-mass planar system with movements in the path of the ground motion for the attached tree-building system is developed, first. Then an output-feedback controller based on the Kalman filter and optimal control theories is designed for the main structure, to guarantee the stability of the closed-loop system to achieve an arranged level of disturbance attenuation. Consequently, for investigating the effectiveness of the proposed method on the main and neighbor structures, some numerical simulations using historically recorded ground accelerations, are considered and the results will be discussed.

Key words: Active control, seismic response, vibration attenuation, lumped-mass model

1. INTRODUCTION

More and more skyscrapers have been constructed because of the limitation of land, particularly in big towns in recent years. Nevertheless, at the same time, strong earthquakes and wind occur frequently. For example, numerous structures were damaged or collapsed during the 1994 Northridge, 1995 Kobe, 1999 Duzce, 1999 Chi-Chi and the most recent 2008 Winchuan earthquakes, resulted not only in significant economic losses but also large loss of lives. As buildings become higher, structural stability and strength are challenged and cannot be guaranteed only by high quality materials. Therefore, the requirement of Structural Vibration Control (SVC) techniques for seismic-excited or wind-excited structures becomes further important (Sandell et al., 1978; Housner et al., 1997; Spencer and Sain, 1997; Alkhatib and Golnaraghi, 2003; Soong and Cimellaro, 2009).

Advanced means of SVC techniques can be categorized into the passive control systems and active, semi active, or hybrid control schemes. The main subcategories of passive control systems are the base isolation and the passive energy dissipation systems (Dolce et al., 2000; Ozbulut and Hurlebaus, 2011; Chakraborty and Debbarma, 2011; Zhang and Balendra, 2013). Active, semi-active, and hybrid control schemes are a natural evolution of passive control tools (Lee, 2012; Bitaraf et al., 2010; Park et al., 2003). The devices of this category are part of an integrated system, with real time processing controllers and sensors, all installed to the structure. They act concurrently with the excitation to provide improved structural behavior for progressed service and safety. The use of active, semi-active and the combination of passive, active or semi-active systems as a means to protect the structures against seismic excitations has been attended considerably in the recent years.

During the last few years numerous control algorithms and devices have been established, improved and studied by various groups of researchers in this field of research. To illustrate, Lu et al. (2003) and Du and Zhang (2008) applied classical $H_2$ and $H_{\infty}$ theories, Du and Zhang (2007) and Zhang and Shi (2008) used $L_2$ and $L_{\infty}$ theories, Mahmoud et al. (2000) and Balandin and Kogan (2005) utilized optimal control, sliding mode control was used by Guctu (2006) and Manjunath and Bandyopadhyay (2009), Bucz et al. (2008) developed a new approach PID control, Madan (2005) and Zapateiro et al. (2009) used neural networks, fuzzy logic was applied to structural systems by Pouzezunali et al. (2007) and Shook et al. (2008), independent modal space control was used by Park et al. (2004), to diminish building vibration under earthquake or wind loads. By the improvement of active structure vibration control methods, studies of building vibration control have already been converted from theories to practical applications, magnetorheological (MR) dampers, for instance, have been widely studied and applied for vibration reduction by Zapateiro et al. (2009), in which a series of investigations run on a real-time hybrid testing have been done, and Goto et al. (2008) presented a new deterioration prediction method for conservation of rotating equipment.
Moreover for practical aspects, ever more limitations of real systems are taken into account, for example actuator saturation (Lim, 2008), uncertainties of structure models and controllers (Song et al., 2007; Wang et al., 2001), and controllers or sensors with time delay (Li et al., 2008). In addition, Cole et al. (2008) presented a technique for reaching robust vibration control of flexible structures under contact and establishes a robust $H_\infty$ cost bound for the closed-loop system; Du et al. (2008) and Karimi et al. (2009) presented a mixed $H_2/H_\infty$ design scheme to control tall buildings, while Du et al. (2008) considered the pole placement and a reduced-order model and Karimi et al. (2009) dealt with base-isolated models; Park et al. (2008) proposed a bilinear pole-shifting technique with $H_\infty$ control technique for dynamic response attenuation of large structures. All the aforementioned works reduce building vibration effectively.

Even though the most remarkable cases of SVC for seismic protection are mostly those including huge structures as long-span bridges or tall skyscrapers, it should also be emphasized that the existence of a wide variety of smaller structures for which a particular level of seismic protection might be requested such as emergency power plants, central police stations and hospitals. Besides, it is to be considered that in spite of the medium or small size of individual structures, the whole structural system could be extremely complex, including two or more adjacent buildings and a group of attached substructures, which may require different levels of seismic protection. The seismic excitations on multi-structure systems can lead to undesirable interactions among the different substructures such as inter-structure collisions that might cause severe structural damage. Additionally, the mechanical properties of the structural system might vary due to changes in masses of each part and material characteristics. Accordingly, SVC designs for multi-structure systems should aim at two objectives: (i) decreasing the vibrational response of the main substructure and (ii) avoiding unwanted inter-structure interactions such as pounding events.

The main objective of this study is to demonstrate the positive features associated with the LQG output-feedback control for seismic alleviation of multi-structure buildings. For this purpose a general model of a shear-frame multi-structure as a lumped-mass planar system with movements in the path of the ground motion for the attached tree-building system is developed. An output-feedback controller based on the Kalman filter theory and optimal control theory is designed for the main structure, to achieve an appropriate level of disturbance rejection. To illustrate the performance of the proposed control method, an earthquake-excited multi-structure consisting of three buildings with active controller system on the main building is used. For the numerical simulations, historically recorded ground accelerations, i.e., the El Centro (1940) and Kobe (1995) earthquakes are considered as external disturbances. Finally, the results of numerical simulations are discussed to investigate the capability of the proposed method.

2. MATERIALS AND METHODS

2.1. Multi-structural building model

In this section, a simplified shear-frame structure modeled as a lumped-mass planar system with displacements in the direction of the ground motion for a three-building coupled system shown in Fig. 1 is presented. The buildings’ motion can be described by the following second-order model,

$$M \ddot{q}(t) + C \dot{q}(t) + K q(t) = T_u u(t) + T_w w(t),$$  

(1)

where $M$ is the mass matrix; and $C$ and $K$ are the total damping and the total stiffness matrices, respectively, including the damping and stiffness coefficients of the buildings, and also the damping

$$q(t) = [q_1(t), ..., q_{i_1}(t), q_2(t), ..., q_{i_2}(t), ..., q_{i_n_1}(t), ..., q_{i_n_k}(t)]^T$$

(2)

where $q_i(t)$ represents the displacement of the $i$-th story in the $j$-th building corresponding to the time $t$. Regarding the actuation system, we assume that a set of interstory force actuators located between every two neighboring floors has been implemented in the main building, as indicated in Fig. 1, where $u_i(t)$ is the actuation force exerted by actuator that is implemented between stories $i-1$ and $i$ in the main building at time $t$. The vector of control forces, which is produced by actuators, has the structure as

$$u(t) = [u_1(t), ..., u_{n_s}(t)]^T$$

(3)
As shown in Fig. 1, the force delivered by the actuation device produces a pair of opposite forces acting on floors $i-1$ and $i$ of the main building. This actuation scheme is modeled by means of the control location matrix $T_u$. Finally, $T_w$ is the disturbance input matrix and $w(t)$ is the ground acceleration. Note that the explicit dependence on time of $u_i(t)$ and $w(t)$ has been omitted in Fig. 1 to simplify the notation; this will also be done in the sequel when convenient. The mass matrix in Eq. (1) has the block diagonal structure as,

$$
M = \begin{bmatrix}
M^{(1)} & [0]_{n_1 \times n_2} & [0]_{n_2 \times n_3} \\
[0]_{n_2 \times n_1} & M^{(2)} & [0]_{n_2 \times n_3} \\
[0]_{n_3 \times n_1} & [0]_{n_3 \times n_2} & M^{(3)}
\end{bmatrix}
$$

(4)

where $[0]_{r \times s}$ is an $r \times s$ zero-matrix and $M^{(j)}$ is the mass matrix of the $j$-th building, and

$$
M^{(j)} = \begin{bmatrix}
m^{(j)}_1 & \cdots & 0 \\
\vdots & \ddots & \vdots \\
0 & \cdots & m^{(j)}_n
\end{bmatrix}, \quad (j = 1,2,3)
$$

(5)

The total damping matrix can be written in the form

$$
C = C_B + C_L
$$

(6)

where

$$
C_B = \begin{bmatrix}
C^{(1)} & [0]_{n_1 \times n_2} & [0]_{n_2 \times n_3} \\
[0]_{n_2 \times n_1} & C^{(2)} & [0]_{n_2 \times n_3} \\
[0]_{n_3 \times n_1} & [0]_{n_3 \times n_2} & C^{(3)}
\end{bmatrix}
$$

(7)

is a block diagonal matrix corresponding to the internal damping of the buildings with tridiagonal blocks as.
and $c_i^j$ denotes the damping coefficient of the $i$-th story in the $j$-th building. The damping matrix $C_L$ corresponds to the linking system and can be written as a block matrix as follows:

$$C_L = \begin{bmatrix} \tilde{c}_{n_1 \times n_1} & \tilde{c}_{n_1 \times n_2} & \tilde{c}_{n_1 \times n_3} \\ \tilde{c}_{n_2 \times n_1} & \tilde{c}_{n_2 \times n_2} & 0 \\ \tilde{c}_{n_3 \times n_1} & 0 & \tilde{c}_{n_3 \times n_3} \end{bmatrix}$$  \tag{9}$$

where

$$[\tilde{c}]_{n_1 \times n_1} = \begin{bmatrix} c_{11}^{12} + c_{11}^{13} & \ldots & 0 & \ldots & 0 & \ldots & 0 \\
\vdots & \ddots & \vdots & \ddots & \vdots & \ddots & \vdots \\
0 & \ldots & c_{n_1}^{12} + c_{n_1}^{13} & 0 & \ldots & 0 & \ldots \\
0 & 0 & \ldots & c_{n_1}^{21} & \ldots & \ldots & \ldots \\
\vdots & \vdots & \ddots & \vdots & \ddots & \ddots & \vdots \\
0 & \ldots & 0 & \ldots & 0 & c_{n_1}^{n_1} & \ldots \\
0 & \ldots & 0 & \ldots & 0 & \ldots & 0 \end{bmatrix}, \quad j = 2, 3 \tag{10}$$

$$[\tilde{c}]_{n_j \times n_j} = \begin{bmatrix} c_{1j} & \ldots & 0 \\
\vdots & \ddots & \vdots \\
0 & \ldots & c_{n_j}^{1j} \\
0 & \ldots & 0 \\
\vdots & \ddots & \vdots \\
0 & \ldots & 0 \end{bmatrix}, \quad j = 2, 3 \tag{11}$$

where $c_r^{1j}$ is the damping coefficient of the $r$-th linking element between the first building and the $j$-th building, and $k$ is equal to the subscript $j$ in which $n_j$ has the maximum value. Note that, it is assumed the first building is the tallest one i.e. $n_1 > n_2, n_3$.

The total stiffness matrix can also be written in the form $K = K_R + K_L$, with

$$K_R = \begin{bmatrix} K^{(1)} & [0]_{n_1 \times n_2} & [0]_{n_1 \times n_3} \\
[0]_{n_2 \times n_1} & K^{(2)} & [0]_{n_2 \times n_3} \\
[0]_{n_3 \times n_1} & [0]_{n_3 \times n_2} & K^{(3)} \end{bmatrix}$$

$$K_L = \begin{bmatrix} \tilde{K}_{n_1 \times n_1} & \tilde{K}_{n_1 \times n_2} & \tilde{K}_{n_1 \times n_3} \\
\tilde{K}_{n_2 \times n_1} & \tilde{K}_{n_2 \times n_2} & [0]_{n_2 \times n_3} \\
\tilde{K}_{n_3 \times n_1} & [0]_{n_3 \times n_2} & \tilde{K}_{n_3 \times n_3} \end{bmatrix} \tag{12}$$

where matrices $K^{(j)}$ and $\tilde{K}$ can be obtained from Eqs. (8), (10) and (11), by replacing the damping coefficients $c_i^j, c_i^{12}$ and $c_i^{13}$ by the corresponding...
stiffness coefficients $k^j$, $k^{12}$ and $k^{13}$. The control location matrix $T_u$ has the following structure

$$
T_u = \begin{bmatrix}
T_u^{(1)} & [0]_{n_1 \times n_2} & [0]_{n_2 \times n_3} \\
[0]_{n_2 \times n_1} & T_u^{(2)} & [0]_{n_2 \times n_3} \\
[0]_{n_3 \times n_1} & [0]_{n_3 \times n_2} & T_u^{(3)}
\end{bmatrix}
$$

(13)

where $T_u^{(j)}$ denotes the control location matrix of the $j$-th building

$$
T_u^{(j)} = \begin{bmatrix}
1 & -1 & 0 & \cdots & 0 \\
0 & 1 & -1 & \cdots & 0 \\
\vdots & \vdots & \ddots & \cdots & \vdots \\
0 & 0 & 0 & \cdots & 1
\end{bmatrix}
$$

(14)

Note that when there are not any actuators in the neighborhood buildings, $T_u^{(2)}$ and $T_u^{(3)}$ are replaced by $[0]_{n_2 \times n_2}$ and $[0]_{n_3 \times n_3}$, respectively. Finally, the disturbance input matrix can be written in the form

$$
T_w = -M(1)_{n_1+n_2+n_3}
$$

where $\{1\}_{n_1+n_2+n_3}$ is a column vector of dimension $n_1 + n_2 + n_3$ with all its entries equal to 1.

Now we take the state vector

$$
x(t) = [q(t), \dot{q}(t)]^T
$$

(15)

and derive the following first-order state-space model from the second-order model of the Eq. (1),

$$
\begin{aligned}
\dot{x}(t) &= Ax(t) + Bu(t) + Eu(t) \\
y(t) &= C_y x(t) + D_y u(t)
\end{aligned}
$$

(16)

The state matrix in Eq. (16) can be written as

$$
A = \begin{bmatrix}
[0]_8 & I_8 \\
-M^{-1}K & -M^{-1}C
\end{bmatrix}
$$

(17)

where $[0]_r$ denotes an $r \times r$ zero matrix and $I_r$ is the identity matrix of order $r$. The control and disturbance input matrices have, respectively, the following form

$$
B = \begin{bmatrix}
[0]_8 \\
-M^{-1}T_u
\end{bmatrix},
$$

$$
E = \begin{bmatrix}
[0]_8 \times 1 \\
-\{1\}_8
\end{bmatrix}
$$

(18)

Regarding the output matrix, we will consider five different cases. The vector of story displacements relative to the ground is

$$
y_d = q(t)
$$

(19)

$y_d$ can be obtained using the output matrix (19).

$$
C_y = [I_8, [0]_g_2].
$$

(20)

The interstory drifts are the relative displacements between consecutive floors of the same building, and can be defined as

$$
\begin{aligned}
\{y_y^{1j}\}_i(t) &= q^{j}_i(t), \\
\{y_y^{2j}\}_i(t) &= q^{j}_i(t) - q^{j-1}_i(t) & 1 \leq i \leq n_j,
\end{aligned}
$$

(21)

The vector of interstory drifts is as,

$$
y_y(t) = [\{y_y^{1j}\}_1(t), ..., \{y_y^{1j}\}_n_j(t), \{y_y^{2j}\}_1(t), ..., \{y_y^{2j}\}_n_j(t), \{y_y^{3j}\}_1(t), ..., \{y_y^{3j}\}_n_j(t)]^T
$$

(22)

The vector of interstory drifts can be computed with the following output matrix.

$$
C_y = \begin{bmatrix}
\tilde{C}_{y_1}^{(1)} & [0]_{n_1 \times n_2} & [0]_{n_2 \times n_3} & [0]_{n_1 \times (n_2+n_3)} \\
[0]_{n_2 \times n_1} & \tilde{C}_{y_2}^{(2)} & [0]_{n_2 \times n_3} & [0]_{n_2 \times (n_2+n_3)} \\
[0]_{n_3 \times n_1} & [0]_{n_3 \times n_2} & \tilde{C}_{y_3}^{(3)} & [0]_{n_3 \times (n_2+n_3)}
\end{bmatrix}
$$

(23)

where

$$
\tilde{C}_{y_j}^{(j)} = \begin{bmatrix}
1 & 0 & \cdots & 0 & 0 \\
0 & 1 & \cdots & 0 & 0 \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
-1 & 1 & \cdots & 0 & 0 \\
0 & 0 & \cdots & 1 & 0 \\
0 & 0 & \cdots & -1 & 1
\end{bmatrix}, \quad j = 1,2,3.
$$

(24)
As a third case, we introduce the interbuilding approaches to describe the approaching between the stories placed at the i-th level in the adjacent buildings

$$\{y_{ij}(t)\} = -\{\xi_i(t) - \xi_j(t)\}, \quad 1 \leq i \leq \min\{n_i, n_j\}, \quad j = 2, 3. \quad (25)$$

For considered three-building system the vector of interbuilding approaches will be as,

$$C_{\gamma} = \begin{bmatrix} I_{n_2} & [0]_{n_2 \times (n_2 + n_3)} & -I_{n_2} & [0]_{n_2 \times n_3} & [0]_{n_2 \times (n_2 + n_3 + n_3)} & [0]_{n_2 \times (n_2 + n_3 + n_3 + n_3)} \end{bmatrix} \quad (27)$$

The vector of interbuilding approaches can be obtained using the output matrix (27).

Note that, as it was mentioned before, the middle building is the tallest one.

It should be observed that positive values of the interbuilding approaches (25) correspond to a reduction in the distance between the corresponding stories. Clearly, for a given interbuilding separation, large values of the interbuilding approaches may result in interbuilding collisions. To avoid the computational complexity associated with the pounding impacts (Jankowski, 2005), the different seismic response simulations presented in this paper are conducted under the assumption that the interbuilding separation is large enough to avoid collisions. In this case, the maximum values of the interbuilding approaches can be understood as lower bounds of safe interbuilding separation.

In the control of civil engineering structures, absolute acceleration measurements are readily available (Tan and Agrawal, 2009). So, assuming that accelerometers are employed and each of them is located at each floor of the main building, the sensors outputs’ vector will be as

$$\{y_{sen}(i)(t)\} \quad i = 1, ..., n_3$$

And it can be obtained using the output matrices

$$y_{sen}(t) = [y_{sen}(1)(t), ..., y_{sen}(n_3)(t)]^T \quad (28)$$

where $X(i, :)$ represents the i-th row of the matrix $X$. It should be noted that the magnitude of the disturbance input matrix $W(t)$ must be added to the calculated acceleration of each story.

In this paper, our goal is to find an output-feedback control system,

$$\dot{z}(t) = A_c z(t) + B_c y_{sen}(t)$$
$$u(t) = C_c z(t) + D_c y_{sen}(t). \quad (30)$$

Such that,
1- The closed-loop system is asymptotically stable,
2- The objective function

$$J = \int_0^\infty [y(t)^T Q y(t) + u(t)^T R u(t)] dt, \quad \text{is minimized}.$$  

2.2. Controller design

Now, following the standard Linear Quadratic Regulator (LQR) design procedure (Gawronski 2004), for a given non-zero initial state $x(0)$, one should find the control input $u(t)$ which puts the system (28) back to the zero ($x = 0$) state in an optimal manner and attain the greatest possible reduction in the vibrational response of the multi-structure system. This can be achieved by minimizing the deterministic performance index (Ogata, 2009)

$$J = \int_0^\infty [y_{sen}(t)^T Q y_{sen}(t) + u(t)^T R u(t)] dt \quad (31)$$

where $Q$ and $R$ are suitably chosen constant weighting matrices concerning the system response and control.
input, such that \( \bar{Q} = \bar{Q}^T \geq 0, \bar{R} = \bar{R}^T \geq 0 \), and it should be noted here that the linear quadratic regulator with output weighting is equivalent to linear quadratic state feedback regulator with weighting matrices \( Q \) and \( R \) obtained by solving the matrix equation (Lewis et al., 1995)

\[
\begin{bmatrix}
\bar{Q} & 0 \\
0 & \bar{R}
\end{bmatrix}
= 
\begin{bmatrix}
C^T & 0 \\
0 & R
\end{bmatrix}
\begin{bmatrix}
Q & 0 \\
0 & Q
\end{bmatrix}
\begin{bmatrix}
C & 0 \\
0 & I
\end{bmatrix}.
\]  

(32)

The first step in the solution of the LQG problem consists of finding the optimal control to a deterministic linear quadratic regulator (LQR) problem: namely, the above LQG problem without \( w_d \) and \( w_n \). The optimal solution to this problem can be written in terms of the simple state feedback law (Ogata, 2009)

\[
u(t) = -K_e \hat{x}(t),
\]  

(33)

where \( \hat{x} \) is the estimated state, and \( K_e = R^{-1}B^TX \), in which \( X(X = X^T \geq 0) \) is the unique positive-semi definite solution of the algebraic Riccati equation

\[
A^TX + XA - XB^TR^{-1}B^TX + Q = 0.
\]  

(34)

The next step is to find an optimal estimate \( \hat{x} \) of the state \( x \) so that \( E[(x - \hat{x})^T(x - \hat{x})] \) is minimized, where \( E \) is the expectation operator.

\[
\frac{d}{dt} (\hat{x}(t)) = 
\begin{bmatrix}
A - BK_e & BK_e \\
0 & A - K_e Q
\end{bmatrix}
\hat{x}(t) + 
\begin{bmatrix}
Ew_d \\
Ew_d - K_e w_n
\end{bmatrix}
\]

(37)

where \( e(t) = x(t) - \hat{x}(t) \). This demonstrates that the closed-loop poles are simply the combination of the poles of the deterministic LQR system (i.e., the eigenvalues of \( A - BK_e \)) and the poles of the Kalman filter (i.e., the eigenvalues of \( A - K_e Q \)), which is exactly as predicted by the Separation Theorem.

3. RESULTS AND DISCUSSIONS

To design the active controllers and to perform the numerical simulation of the seismic response corresponding to the designed controller, a particular three-building system formed by a main five-story building adjacent to two three-story buildings has been chosen. The nominal values of the system parameters and their bounds of variation are used as those are given in Table 1.

In the control design procedure \( Q = 10^6, R = 10^{-3} \), \( w_d = 1 \) and \( w_n = 10^{-4} \) is considered.

The measurement noise, \( w_n \), and the process noise, \( w_d \), are generally assumed to be uncorrelated zero-mean Gaussian stochastic processes with constant power spectral density matrices, \( \mathcal{W}_n \) and \( \mathcal{W}_d \), respectively, where \( E[w_n(t)w_n(t')^T] = \mathcal{W}_n \delta(t - t'), \) and \( E[w_d(t)w_d(t')^T] = \mathcal{W}_d \delta(t - t') \) (Ogata, 2009). Also, the optimal state estimate is given by a Kalman filter, which estimates the state of the system in presence of noisy measurements, and is independent of \( Q \) and \( R \). The Kalman filter has the structure of an ordinary state estimator with

\[
\dot{\hat{x}}(t) = A \hat{x}(t) + B u(t) + K_e [y_{sen}(t) - C \hat{x}(t)],
\]  

(35)

where \( K_e = Y C^T \mathcal{W}_n^{-1} \) is the optimal choice for observer gain which minimizes the mean square error \( E[(x - \hat{x})^T(x - \hat{x})] \), and \( Y = Y^T \geq 0 \) is the unique positive-semi definite solution of the estimator algebraic Riccati equation (Ogata, 2009)

\[
YA^T + AY^T + C^TY \geq 0.
\]  

(36)

Lastly, using the state-space realization, the state feedback law (33), and the estimated state Eq. (35), after some straight forward manipulations, one can obtain the closed-loop system dynamic equations in the form

A set of numerical simulations is conducted in order to compare the vibrational response of the three-building structure with and without controller due to two medium-sized and large-sized seismic excitations. For investigation of a medium-sized disturbance, the full-scale North-South El Centro 1940 seismic record obtained at the Imperial Valley Irrigation District substation in El Centro, CA, during the Imperial Valley earthquake of May 18th, 1940, has been used as a ground acceleration input. This is a medium-sized seismic disturbance with an acceleration peak of about \( 3 \text{ m/s}^2 \) (Ohtori et al., 2004) (see Fig. 2(a)). For studying the effectiveness of proposed control strategy when the three-building structure is excited by a large seismic disturbance, we have considered the full scale North-South component of the ground acceleration record obtained at the Kobe Japanese Meteorological Agency station during the Hyogoken-Nanbu earthquake of January 17, 1995. This is a near-field record, corresponding to a close-to-epicentre station, that presents large acceleration peaks which are extremely destructive to tall structures (Huang and
Chen, 2000; Ohtori et al., 2004). In order to give a clear idea of magnitude, the Kobe and El Centro seismic records are presented together in Fig. 2 using the same acceleration range.

Table 1: The values of the multi-structure parameters.

<table>
<thead>
<tr>
<th>Name</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The mass of the i-th story of the 1st building</td>
<td>m_i,i</td>
<td>1.29 × 10^6 kg</td>
</tr>
<tr>
<td>The mass of the i-th story of the 2nd building</td>
<td>m_i,i</td>
<td>0.79 × 10^6 kg</td>
</tr>
<tr>
<td>The mass of the i-th story of the 3rd building</td>
<td>m_i,i</td>
<td>1.79 × 10^6 kg</td>
</tr>
<tr>
<td>The stiffness of the i-th story of the 1st building</td>
<td>k_i,i</td>
<td>2.4 × 10^6 N/m</td>
</tr>
<tr>
<td>The stiffness of the i-th story of the 2nd building</td>
<td>k_i,i</td>
<td>2 × 10^6 N/m</td>
</tr>
<tr>
<td>The stiffness of the i-th story of the 3rd building</td>
<td>k_i,i</td>
<td>2 × 10^6 N/m</td>
</tr>
<tr>
<td>The damping of the i-th story of the 1st building</td>
<td>c_i,i</td>
<td>10^5 Ns/m</td>
</tr>
<tr>
<td>The damping of the i-th story of the 2nd building</td>
<td>c_i,i</td>
<td>10^5 Ns/m</td>
</tr>
<tr>
<td>The damping of the i-th story of the 3rd building</td>
<td>c_i,i</td>
<td>10^5 Ns/m</td>
</tr>
<tr>
<td>The stiffness of the r-th linking element between the 1st building and the 2nd building</td>
<td>k_{r,r}</td>
<td>0 N/m</td>
</tr>
<tr>
<td>The stiffness of the r-th linking element between the 1st building and the 3rd building</td>
<td>k_{r,r}</td>
<td>0 N/m</td>
</tr>
<tr>
<td>The stiffness of the r-th linking element between the 2nd building and the 3rd building</td>
<td>k_{r,r}</td>
<td>3 × 10^6 Ns/m</td>
</tr>
<tr>
<td>The damping of the r-th linking element between the 1st building and the 2nd building</td>
<td>c_{r,r}</td>
<td>10^5 Ns/m</td>
</tr>
<tr>
<td>The damping of the r-th linking element between the 1st building and the 3rd building</td>
<td>c_{r,r}</td>
<td>10^5 Ns/m</td>
</tr>
</tbody>
</table>

Fig. 2: Seismic records: (a) Full scale NS El Centro 1940. (b) Full scale NS Kobe 1995.

As the first case, we consider the earthquake response of the active and passive structures due to North-South El Centro seismic excitation. The Maximum absolute story displacements relative to the ground, maximum absolute interstory drifts, maximum interbuilding approaches, and maximum absolute control forces are displayed in Fig. 3. Figures 3(a) to 3(h) summarize the peak vibrational response for both passive and active structures. In addition, the ideal active control forces with no saturation which use the theoretical control action \( u(t) \) without restriction are shown in Fig. 3(i).

The graphics in Fig. 3 show clearly the appropriate performance exhibited by the designed active control where peak values for the absolute story displacements relative to the ground, absolute interstory drifts and interbuilding approaches are dramatically smaller than those obtained from passive structure. In addition, the vibrational response of the adjacent buildings improved, although the control system has only implemented in the main building.

As the second case, we consider the vibrational response of the active and passive structures due to North-South component of the Kobe seismic excitation. As the previous figure, the maximum absolute story displacements relative to the ground, maximum absolute interstory drifts, maximum interbuilding approaches, and maximum absolute control forces are displayed in Fig. 4. Figures 4(a) through 4(h) summarize the peak vibrational response for both passive and active structures using LQG controller. In addition, the ideal active control forces with no saturation, those use the theoretical control action \( u(t) \) without restriction, is shown in Fig. 4(i).

Figure 4 shows clearly the excellent performance exhibited by the designed active control where peak values for the absolute story displacements relative to the ground, absolute interstory drifts and interbuilding
approaches are dramatically smaller than those obtained from passive structure, for both the main building and the adjacent ones.

By comparison of Figs. 3 and 4, one can see that the performance of the designed controller is more appropriate in a large seismic disturbance. However, control forces in the case of large-sized seismic excitation are dramatically larger than the medium-sized one. So, the capability of actuators for large earthquakes must be considered.

Regarding the vibrational protection of the multi-structure system, the prime aspects associated with the action of the designed output-feedback control system consist of specific substructure protection, high-level protection for moderate and large external disturbances and high-level protection for moderate and large external disturbances. Specific substructure protection implies that appropriate levels of vibrational protection can be provided to individual substructures by implanting the output-feedback control systems in them. Additional protection against interstructure collisions is supplied by the actuators. For medium-sized and large-sized external disturbances, high levels of vibrational attenuation and very small interstructure approaches can be obtained using active devices.

**Fig. 3:** Peak vibrational responses and control forces for North-South El Centro seismic excitation.

### 4. CONCLUSION

An active structural vibration control strategy for seismic protection of general adjacent multi-structures has been proposed. This strategy combines output-feedback control system implemented in the all floors of the main building. Consequently, this strategy is concerned with the LQG controller design considering reasonable range of Gaussian noise and disturbance. From the time response analyses we can conclude that the applied controller attenuates vibration responses of the main and neighborhood buildings under medium-sized and large-sized seismic excitations. Therefore, this active strategy has the ability to maintain desired performance of a complex multi-structural building.
Gudarzi and Zamanian
Application of Active Vibration Control for Earthquake Protection of Multi-Structural Buildings

Fig. 4: Peak vibrational responses and control forces for North-South component of the Kobe seismic excitation.

REFERENCES


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Full Length Research Paper

Effects of Resistance Exercises on Serum Leptin and Some Inflammatory Markers in Obese Males

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Abstract. The main purpose of the present study was to assess the effects of resistance exercise (RE) regimens on leptin concentrations and on risk factors for coronary heart disease in obese sedentary males. Thirty subjects were recruited into this study, 20 control subjects and 20 individuals for resistance exercise. Subjects ranged in age from 20 to 40 years. The subjects reported in the laboratory on the morning after a 12-h fast. Blood (10 ml) was obtained from an antecubital vein, with the subject in an upright position, before exercise and at 10 h after six weeks of resistance training. In conclusion, after resistance exercise, leptin and CRP showed significant differences when compared to resting values. In addition, these values were related to each other after exercise. Other cytokines and different types of subjects should be included in further studies.

Key words: Leptin, IL-6, CRP, Resistance Exercise

1. INTRODUCTION

Obesity is a complex disorder characterized by the accumulation of excess adipose tissue. The prevalence of obesity and its secondary health risks have dramatically increased over the last decades (Mokdad et al., 2003). Obesity is an important risk factor for the development of vascular disorders (Cooke and Oka, 2002; Krauss et al., 1998). Adipose tissue, in addition to the storage of lipids, secretes bioactive peptides termed “adipokines” which act locally and distally through autocrine, paracrine, and endocrine pathways. In obesity, increased production of most adipokines impacts on multiple functions such as appetite, energy balance, immunity, insulin sensitivity, angiogenesis, blood pressure, lipid metabolism and homeostasis, all of which are linked to cardiovascular disease (Ronti et al., 2006).

Discovery of the hormone leptin in 1994 catalyzed the field of obesity research by demonstrating the existence of an afferent hormonal signal from adipose tissue to the central nervous system (Kraemer et al., 2002; Zhang et al., 1994). Leptin is a 16 kDa peptidic hormone produced mainly by adipose tissue, which acts as a signalling mechanism to regulate body-fat content through binding to leptin receptors located in hypothalamic nuclei (Kraemer et al., 2002; Thong et al., 2000). Increases in percent body fat are associated with enhanced adipose tissue synthesis and secretion of leptin in humans (Barbato et al., 2006; Hilton and Loucks 2000). Leptin, commonly termed the obese protein, has been implicated in regulating an array of physiological processes such as appetite, metabolic rate, reproduction, immunity (Kraemer et al., 2002). Leptin has been demonstrated to induce insulin resistance (Houmard et al., 2000). Leptin is involved in the pathogenesis of vascular disease and may represent a link between obesity, diabetes, inflammation and atherosclerosis (Krauss et al., 1998; Livshits et al., 2005). Leptin increases energy expenditure by enhancing sympathetic nervous activity and lipolysis (Kraemer et al., 2002; Fenkei et al., 2006; Konstantinides et al., 2001). It also suppresses appetite through acting on the hypothalamus (Mokdad et al., 2003; Ronti et al., 2006; Mendosa-Nunez et al., 2002). In recent years, leptin has been reported to increase arterial pressure and heart rate by peripherally or centrally mediated mechanisms (Livshits et al., 2005; Franklin 2005; Rahmouni and Haynes 2004). The finding that leptin is linked to heart-disease risk independently from C-reactive protein (CRP), an inflammation marker, strongly suggests that fat may be important in heart-disease risk (Altman 2003; Canavan et al., 2005). Leptin deficiency and resistance against the effects of leptin are each associated with weight gain. Leptin resistance is much more common than leptin deficiency in human obesity (Mokdad et al., 2003; Krauss et al., 1998; Mendosa-Nunez et al., 2002). There are receptors for leptin on the endothelium and on vascular smooth muscle cells. Accordingly, leptin can exert receptor-mediated influences on vessel tone...
and growth. In cell culture, leptin stimulates vascular smooth muscle proliferation (Rahmouni et al., 2004; Singhal et al., 2002). Vascular calcification is also accelerated by leptin in experimental models (Cooke and Oka, 2002; Franklin, 2005). Additionally, leptin induces oxidative stress in endothelial cells (Altman, 2003; Canavan et al., 2005). Accordingly, it is possible that the high level of leptin observed in obesity contributes to its adverse effects on cardiovascular health (Wallace et al., 2001).

Exercise has been shown to reduce leptin levels regardless of weight loss (Bouassida et al., 2006). Young obese but otherwise healthy subjects are characterized by reduced coronary vasoreactivity (Mcgill et al., 2002). It has become of interest to examine whether physical activity, through its disruptive effects on energy balance, sympathetic drive, and hormonal and metabolic homeostasis, affects serum leptin concentration (Zafeiridis et al., 2003). If leptin is reflective of energy balance, it is conceivable that an increase in energy expenditure, i.e. physical activity, may also modulate plasma leptin (Houmard et al., 2000). The effect of exercise on leptin is also potentially important in relation to insulin action (Hickey et al., 1996; Perusse et al., 1997; Pasman et al., 1998; Ryan et al., 2000). Most studies examined the effects of resistant exercise on serum leptin by the utilization of continuous running regimens (Kraemer et al., 2002; Perusse et al., 1997; Racette et al., 1997; Weltman et al., 2000). Most of these studies have reported a reduction or no change in leptin concentrations. Information regarding the response of serum leptin to a single bout of resistance exercise is limited. Zaferidis et al., 2003 reported that leptin concentration had significantly decreased 30 min after resistance exercise protocols compared with the respective baseline value, but the decline in serum leptin compared with that observed during the control session. Some authors reported that exercise training reduced fasting leptin disproportionately more in a subgroup of women with high adiposity than in leaner women (Hickey et al., 1996; Houmard et al., 2000). There is thus the potential that individuals with larger fat masses respond differently to exercise than leaner subjects in terms of leptin (Houmard et al., 2000). Evidence suggests that, in trained individuals, acute exercise has no effects on circulating leptin levels (Weltman et al., 2000). Exercise can improve metabolic risk variables such as insulin and leptin in overweight and obese post-menopausal women (Barbato et al., 2006). Leptin concentrations exhibited a delayed reduction in the systemic circulation after a resistance exercise protocol (Zafeiridis et al., 2003). Leptin response patterns are a direct result from the intensity and duration of high-energy expenditure and the subsequent excess post-exercise oxygen consumption of the acute resistance exercise protocol (Nindl et al., 2002). In addition, energy expenditure, in exercise is the most important factor that affects leptin concentrations (Kraemer et al., 2002; Zafeiridis et al., 2003).

Although many studies have been published about the effects of exercise on leptin, numerous questions remain to be answered. It is necessary to compare the effects of different exercise protocols on leptin levels in males and females. There is clear evidence for the importance of exact control of energy balance in leptin and exercise studies (Hilton and Loucks, 2000). The evidence that leptin levels decline 9 h after resistance exercise suggests that there is a delayed reduction in leptin that may be due to energy imbalance (Nindl et al., 2002). Thus, in order to determine the true dynamics of exercise-induced leptin responses, studies should determine changes in leptin concentrations for much longer periods of time following exercise. The studies should involve strict controls of energy balance. The main purpose of the present study was to assess the effects of resistance exercise (RE) regimens on leptin concentrations and on risk factors for coronary heart disease in obese sedentary males.

2. MATERILAS AND METHODS

2.1. Subjects

Thirty subjects were recruited into this study, 20 control subjects and 20 individuals for resistance exercise. Subjects ranged in age from 20 to 40 y (Table 1). The control subjects had a mean body mass index of 32.5±1.1 kg/m2. All subjects signed informed consent. Individuals taking insulin or with symptomatic coronary artery disease, peripheral vascular disease, uncontrolled hypertension or any other metabolic diseases were excluded from the study. Both the control and exercise subjects had participated in regular exercise for the preceding six weeks, and all subjects had the stable body weight. All subjects were non-smokers.

<table>
<thead>
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<th>Table 1: Subject characteristics</th>
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<tr>
<td>Age (y)</td>
</tr>
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<tr>
<td>BMI (kg/m²)</td>
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<tr>
<td>Experimental (n=20)</td>
</tr>
<tr>
<td>31.2±2.6</td>
</tr>
</tbody>
</table>
2.2. Blood sampling

The subjects reported in the laboratory on the morning after a 12-h fast. The resistance sessions as well as the control sessions were conducted at the same time of the day in each subject to avoid the effects of fasting and circadian rhythm. The time each exercise session started was adjusted so that the blood samples drawn at 10 h of recovery were obtained at the same time of the day for all sessions. Blood (10 ml) was obtained from an antecubital vein, with the subject in an upright position, before exercise, immediately after exercise and at 10 h of recovery. Blood was collected in glass vacutainers, allowed to clot at room temperature, and centrifuged for 30 min at 800×g at 4°C. After centrifugation, serum was aliquoted into a storage vial in liquid nitrogen, and stored at –80°C for later analysis. Leptin and CRP concentrations were determined using an enzyme-linked immunosorbent assay from Linco Research Inc., (St Charles, MO, USA) and Immulite (Diagnostics Products Corp., Los Angeles, CA, USA), respectively. The sensitivities of these kits were 0.01 ng/ml, and the intra- and interassay coefficients of variation were 7.8% and 5.1%, respectively. The limit of detection and the intra- and interassay coefficients of variation were 0.15 μIU/ml, 5.3% and 9.5%, respectively.

2.3. Body composition

On the first and last testing day, subject height and weight were measured. Sagittal diameter and waist measurements were taken at the umbilicus. Body composition was measured utilizing a Quantum Bioelectrical Impedance Analysis Machine (BIA101Q) by RJL Systems. All subjects were measured between 08:00 and 09:00 h and were in a hydrated state, such that fluids were not restricted and no caffeine had been consumed in the previous 24 h. The premenopausal women were studied in the same phase of their menstrual cycle pre- and post-training.

2.4. Diet

Subjects were asked to consume the same diet prior to each testing period. They were asked to record their diet the day prior to the blood sampling day. After the first sampling day, subjects were reminded what to eat on the days prior to the following sampling days. To ensure compliance, all subjects kept a dietary record on the day prior to the sampling day.

2.5. Resistance exercises training

All subjects performed six weeks of progressive, resistance training. Subjects trained at 80% of 3RM, three times per week. All training sessions were supervised and conducted on alternate days. For each muscle group, the subject was required to complete three sets of 8 – 12 repetitions to failure. Three sets of 15 abdominal crunches were also prescribed. Once subjects were able to complete the 12 repetitions, the weight was increased by 2.3 kg. At the completion of the training, the subjects repeated a 3RM.

2.6. Statistical analysis

The statistical analysis was run using the Statistical Package for the Social Sciences (SPSS, version 8.0). All data are expressed as mean±s.e. An analysis of variance (ANOVA) with repeated measures was used to evaluate the leptin, CRP and IL-6 differences; group (control vs experimental) by time (pre-training vs post training).

3. RESULTS

In Table 2, mean and standard deviation of age, height, weight, body masses were shown. Table 3 shows mean and standard deviation for leptin, CRP and IL-6 before and after training. The results of Tables 3 show that there is significant difference between leptin, CRP and IL-6 concentrations before and after training to a resistance training group.

Table 2: Mean and standard deviation of age, height, weight and body mass index

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>Resistance</th>
<th>control</th>
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<tr>
<td></td>
<td>pre</td>
<td>post</td>
</tr>
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<td>WEIGHT</td>
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<td>---</td>
</tr>
<tr>
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4. DISCUSSION

Previous studies have reported conflicting findings regarding the leptin response to exercise. Acute resistance exercise has been reported to have no impact (Livshits et al., 2005; Fenkci et al., 2006; Konstantinides et al., 2001; Franklin, 2005; Rahmouni et al., 2004; Altman, 2003) or to decrease plasma leptin levels in these studies (Mendosa-Nunez et al., 2002). After 20 weeks of training a decrease in leptin levels was observed in men, but only if decreases in body fat occurred (Franklin, 2005). Recent work has suggested that leptin levels may not only indicate the quantity of adipose tissue but may reflect disturbances, in energy balance, disturbances which may not manifest themselves for a number of hours after exercise (Bouassida et al., 2006). In the present study, we observed a significant decrease in leptin concentrations 24 h after a resistance exercise in experimental subjects, and only a slight decrease in control men. Further this decrease was an acute response because 6 weeks of resistance training resulted in only slight changes in the leptin concentrations compared to pre-training values when resting samples were taken 72 h post-exercise. Twenty-four hours post-exercise, we observed a 30% decrease in leptin concentrations in the experimental subjects, and a 7% decrease in the control subjects. The decrease observed in the experimental subjects is similar to that observed in moderately trained is similar to a decrease observed with weight loss with a diet and exercise program 24h. In addition, an exercise bout causing a 28% increase in 24 h energy expenditure, while maintaining energy balance, significantly decreased peak and average 24 h plasma leptin levels by 20% compared to pre-exercise values. They also noted that this effect could only be detected after 24 h, but not immediately after the exercise bout. It was suggested that the delay in leptin response was due to the time needed for changes in on gene expression in adipose tissue (Singhal et al., 2002; Weltman et al., 2000). This could potentially explain why many earlier studies did not observe a change in leptin levels immediately post-exercise (Livshits et al., 2005; Fenkci et al., 2006; Konstantinides et al., 2001; Franklin, 2005; Rahmouni et al., 2004; Altman, 2003). Recently, Livshits et al., 2005; Bouassida et al., 2006 have noted no change in leptin concentrations with exercise. Hilton and Loucks, 2000 stated that exercise stress per se does not have a suppressive effect on either the 24 h mean or amplitude of the diurnal rhythm of leptin release, other than impacting energy availability. These authors state that low energy availability to the tissues or a negative energy balance has a much greater impact on leptin release than the exercise stress. In addition to a negative energy balance, it is possible that the decreased leptin concentrations in the present study were due to reduced glucose availability in the post-exercise period (Bouassida et al., 2006). Intense aerobic30 and anaerobic exercise 31 have been shown to significantly decrease muscle glycogen. Our resistance training protocol involved whole-body lifting at 80% of 3RM and most likely decreased glycogen stores.

We know that 72 h following our 6 weeks of training no decrease in mean plasma leptin levels was observed, but we are unable to conclusively state that a chronic acute effect at lower leptin levels occurs with six weeks of resistance training.

CRP is an inflammatory index in the human body and a predictor of heart-disease risk at rest. With regard to the effect of exercise on CRP, the results from the current study are similar to those of previous studies, i.e. CRP increased significantly after each acute bout of exercise at the three different intensities. Although post-exercise CRP levels showed an upward trend with higher exercise intensity, a significant difference was not detected among the different exercise intensities. CRP might be related to leptin because CRP binds with the receptor of leptin. This would result in a “leptin resistance” phenomenon as CRP occupies the leptin receptors, and more leptin circulates through the blood. Although the exercise model for this study differed from that of Chen et al. study, this study provided another direction for exploring the relationship between leptin and CRP.

5. CONCLUSION

After resistance exercise, leptin and CRP showed significant differences when compared to resting values. In addition, these values were related to each
other after exercise. Other cytokines and different types of subjects should be included in further studies.

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Zamani et al.
Effects of Resistance Exercises on Serum Leptin and Some Inflammatory Markers in Obese Males


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Saeid Rostami is a PhD student in exercise physiology at University of Tehran. He received his first degree from University of Isfahan in 2008. He obtained degree in Master of Science in exercise physiology from University of Shahrekord in 2011. His current research focuses on cytokines and immunology associated with different types of training. To date, he has published several scientific articles related to physical education field.

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