NEW MODEL FOR BIOMONITORING OF OCCUPATIONAL CHEMICAL EXPOSURE TO VOLATILE ORGANIC COMPOUNDS

MERCADO-CALDERÓN F[1], OROPEZA-HERNÁNDEZ LF[1], ALVARADO-TOLEDO E[1], ALBORES A[2]

[1]Industrial Toxicology Laboratory, Nanchital General Hospital, Petróleos Mexicanos;

[2]Toxicology Department, Center of Research and Advanced Studies, CINVESTAV, México City, México.

Biomonitoring of Occupational Chemical Exposure in the Mexican Petroleum Industry (PEMEX)

- In the **Years 2006-2010,** we have tested a **New Model for Biological Monitoring of Occupational Chemical Exposure to obtain more accurate and precise results,** considering the **low, medium or nonspecificity** of some metabolites, used as **bioindicators of exposure** to **Volatile Organic Compounds (VOCs)**.

- We have analyzed approximately **5, 347** urine samples of **workers** at **risk of exposure** to **Benzene, Toluene, Xylene, Styrene** and **Ethylbenzene**.

- These chemicals are produced, stored and transported by **PEMEX**.

Policy, Procedures and a Work Team that Make Possible the B0HRA

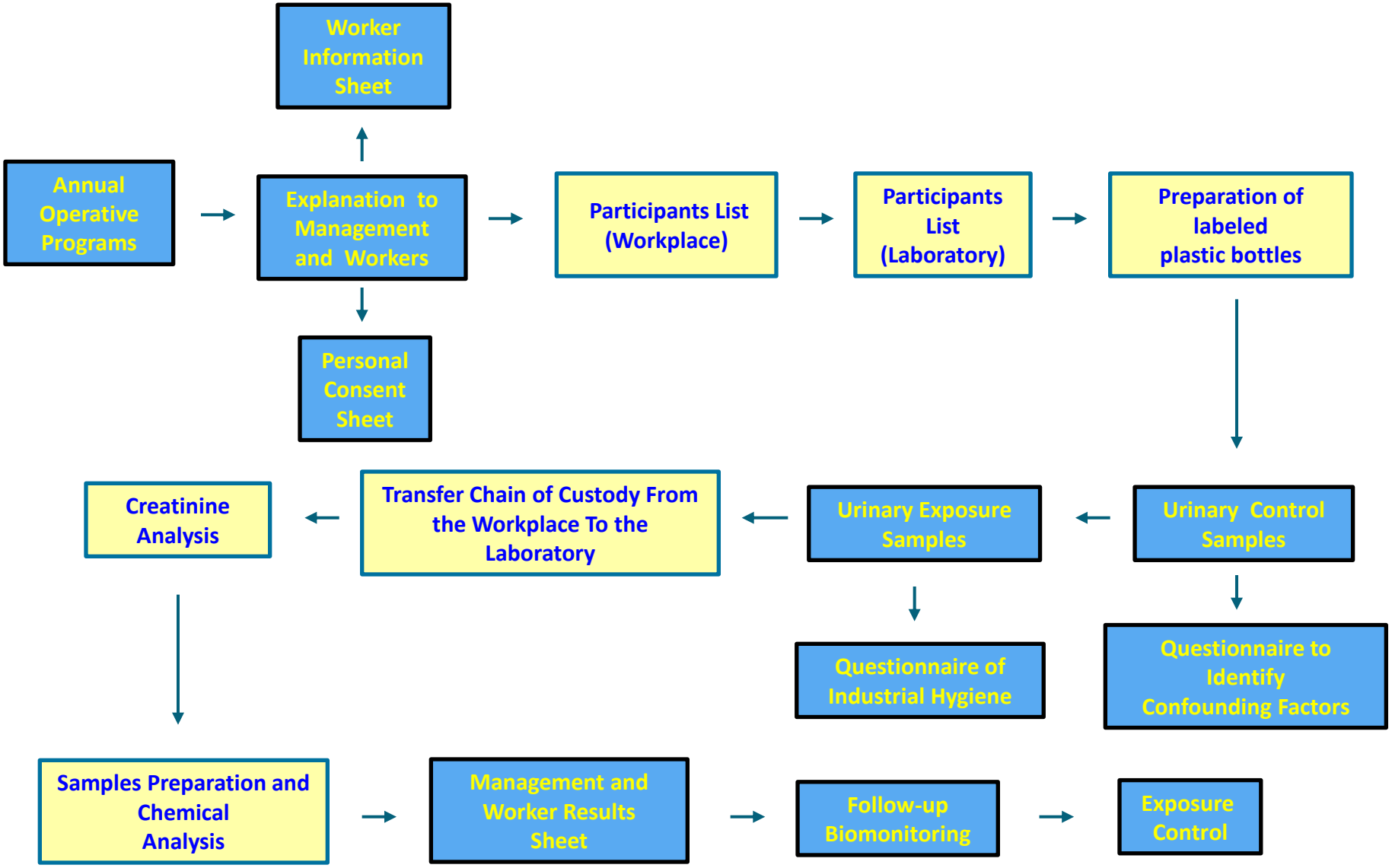
- **Policy and Procedures of PEMEX:**
  - PEMEX Institutional «**SSPA**» : Administrative System for Industrial Safety, Occupational Health and Environmental Protection.
  - PEMEX Institutional «**SAST**»**:** Occupational Health Administrative System.
  - **Technical Guide** of the **BRANCH OF PEMEX HEALTH SERVICES** for Occupational Biomonitoring.
  - **Procedure** of **PEMEX PETROQUIMICA** for Occupational Biomonitoring.

  - **Working Team that participates in the BOHRA:**
    - Workplace Administration
    - Union Representatives
    - Workers themselves
    - Occupational Physicians
    - Industrial Hygiene Personnel
    - Industrial Nurses

Biomonitoring Practice in Our Industrial Toxicology Lab.

Chemical Agent	**Determinant**	***Biological Exposure Index (The underlined concentrations are used in our Laboratory)**	**Specificity** **Ns: Nonspecific**	**Reference**
Benzene	Urinary Phenols (Used in years: 2006-2010) *Urinary S-Phenylmercapturic Acid (Used since 2011)	***50 mg/g Creat. **Tentative Maximum Permissible Concentration: **20 mg/g Creatinine** ***25 microg/g Creat.**	Low, Ns High	***Mexican Official Standard, NOM-047-SSA1-1993. **Lauwerys Robert.,** Casarett & Doull´s Toxicology, Chapter 33: Occupational Toxicology, Edit. Klaassen D. Curtis, Mc Graw Hill, Fifth Edition, p. 999, 1996. *ACGIH, 2009.
Toluene	Urinary Hippuric Acid	***2.5 g/g Creat ***1.6 g/g Creatinine**	Low, Ns	***Mexican Official Standard, NOM-047-SSA1-1993. *ACGIH, 2009, NIC.
Xylenes	Urinary Methylhippuric Acids	*** ***1.5 g/g Creatinine**	High	*** Mexican Official Standard, NOM-047-SSA1-1993. *ACGIH, 2009.
Styrene and Ethylbenzene	Urinary Mandelic Acid plus Phenylglyoxylic Acid	***400 mg/g Creatinine** ***0.7 g/g Creatinine**	Medium, Ns Medium, Ns	*ACGIH, 2009. *ACGIH, 2009.

The Model Proposed for BOHRA of VOCs.



Explanation to Management and Workers

- It is very important to explain the objectives of Biomonitoring and **make participate** the **Administration**, the **Workers** and their **Representatives**.

Worker Information Sheet

Contains information about:

- **What is Biomonitoring of Occupational Chemical Exposure?**
- **Why is useful?**
- **With indications to the workers of:**
  - not to smoke and avoid passive smoking
  - not to eat red meat
  - avoid canned food, plums, blueberries.
  - drink enough water
  - work as every day

Worker Consent Sheet

(International Code of Ethics for Occupational Health Professionals, International Commission on Occupational Health (ICOH), Point 12, 2002).

Contains:

- **Information about the risks** in the practice of Biomonitoring.
- **Consent of each worker through his signature** to participate in the Biomonitoring.
- **The compromise to give to each worker the results** with an understandable interpretation

Types of Baselines

- General Population Baseline
- Non Exposed Workers Baseline
- **Individual Worker Baseline**

Baseline of the **Individual Worker**

- The **Baseline** of the **Individual Worker** is obtained with the measurement of the concentration of the chosen bioindicator in the **Urinary Control Sample**, collected **prior to shift**.

- This is possible, in the case of **VOCs**, because the **Biological Half Life** of **VOCs** is **medium** (**between 1.5 and 5.7 hrs**.), and the Urinary Control Sample represents the **recent exposure**, but not, for instance, in the case of **Metals or other Organic Compounds**, where the **Biological Half Life** is long (**between 10 and 100 hours or more**).

Elimination Half Lives* of the Volatile Organic Compounds (VOCs) Analyzed in our Laboratory

Chemical	Metabolite	Hours
Benzene	Urinary Phenols	5.7
Toluene	Urinary Hippuric Acid	1.5
Xylene	Urinary Methylhippuric Acids	3.6
Styrene	Urinary Mandelic Acid	4
Ethylbenzene	Urinary Phenylglyoxylic Acid	4

Classification of Elimination Half Lives**	Hours
Short Half Life	X< 2
Medium Half Life	2<X< 10
Long Half Live	10< X< 100

*Documentation of the Threshold Limit Values and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists (ACGIH), Sources of Variability in Biological Monitoring, pp. 5-6, 2001.

**V. Fiserova, Scand. J. Work Environ. Health 11, 7-21 (1985).

Benefits of the Individual Worker Baseline

- **To know if the worker had nonoccupational recent exposure to VOCs.**
  - Active and passive smoking.
  - General environmental pollution.
  - Other sources of exposure, such as personal or family jobs or workshops.

- **To integrate personal variables and characteristics:**
  - Age,
  - Weight,
  - Diet,
  - Medication,
  - Metabolism (genotype and phenotype)

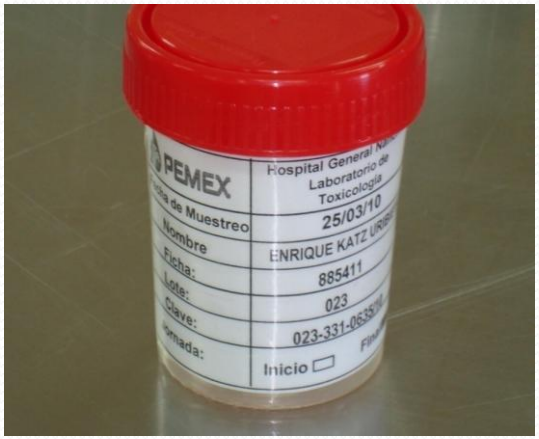
The Urinary Exposure Sample (UES) collected at the end of shift in relation to the Urinary Control Sample (UCS) collected prior to shift

- **To measure the exposure gained during the work day, it is highly reccomended, to take into account both: UES and UCS**

Urinary Exposure Sample – Urinary Control Sample
=
Exposure gained during the work day

First conclusion:

- **<u>Urinary Control Sample</u>** of the worker himself can be considered as the **<u>Gold Standard</u>** for **Biomonitoring of Occupational Exposure to Volatile Organic Compounds.**



Questionnaire to Identify Confounding Factors

Basic Questions about:

- **Active and Passive Smoking**

- **Diet** (Red Meat): Amino acids with benzene rings in their molecular structure: **Phenylalanine,Tryptophan, Tyrosine**.

- **Medication** : We have found the following drugs or medicines ingested or administered to the workers with benzene rings in their molecular structure: **Ampicillin, Amoxycillin, Benzetacyl , Bi-euglucon, Chlorpropamide, Diclofenac, Norvase, Pantoprazol and Paracetamol.**

Questionnaire of Industrial Hygiene

Basic Questions about:

- **Types of Chemicals Used.**

- **Type of Activity** (painting, metal cleaning, equipment maintenance).

- **Use of the Personal Protective Equipment:**

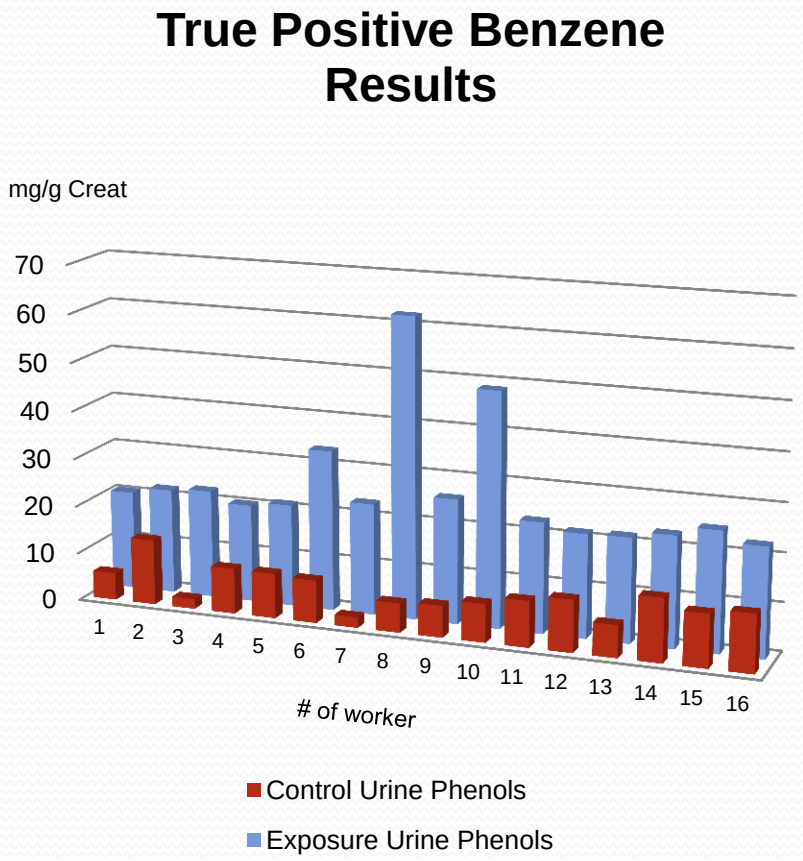
  First, if they have or not. Second, if it is used or not. Third: Types of Respirators and Gloves Used.

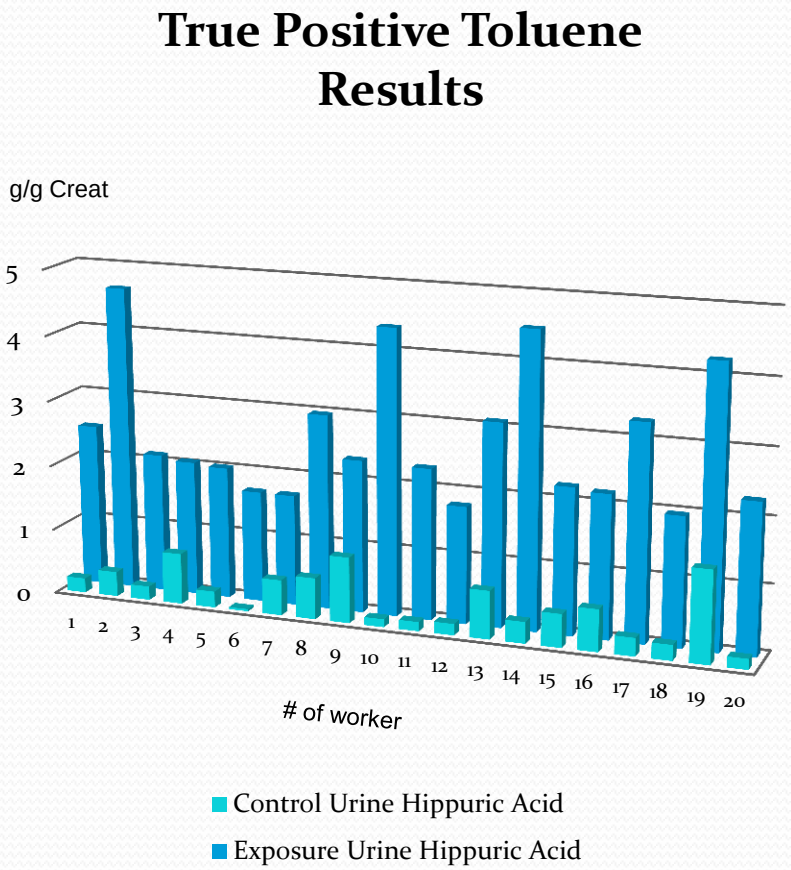
- **If the activity has been made in an open or closed space.**

Results:

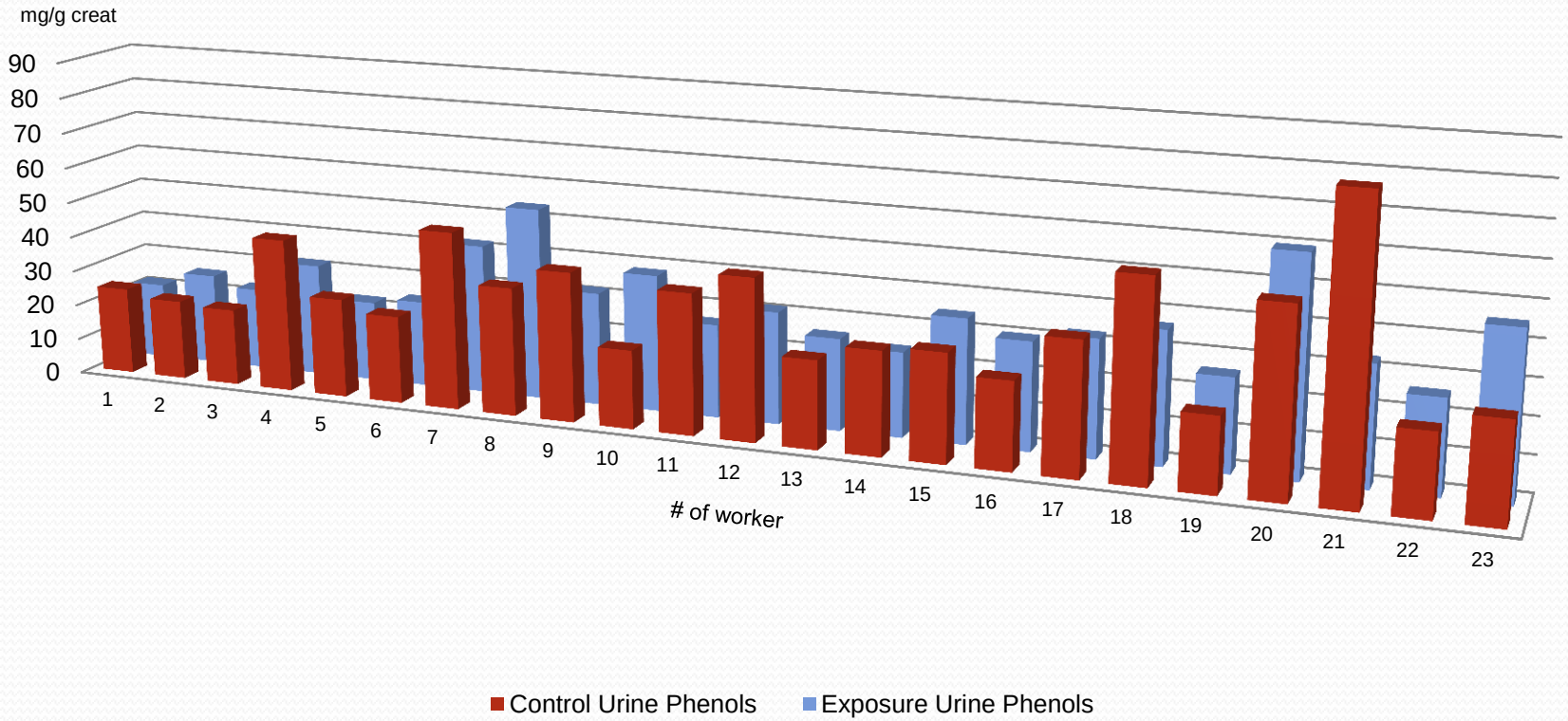
- **Identification of False Positive.**
- **Identification of True Positive.**
- **Prevention and Control of Chemical Exposure through the Biological Monitoring Follow up.**

True Positive Benzene and Toluene Results



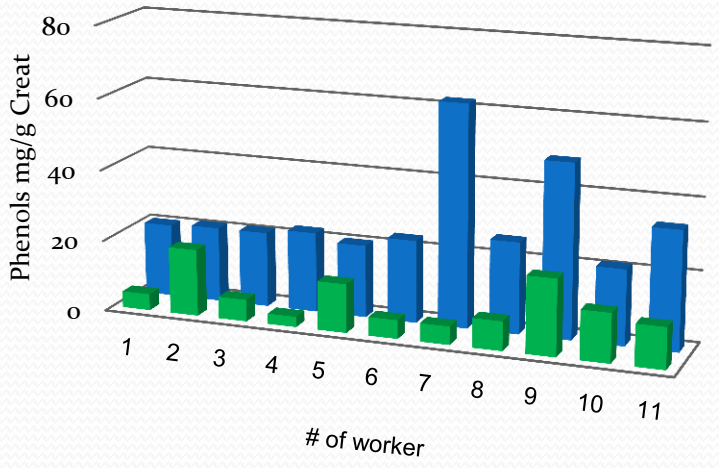


False Positive Benzene Results

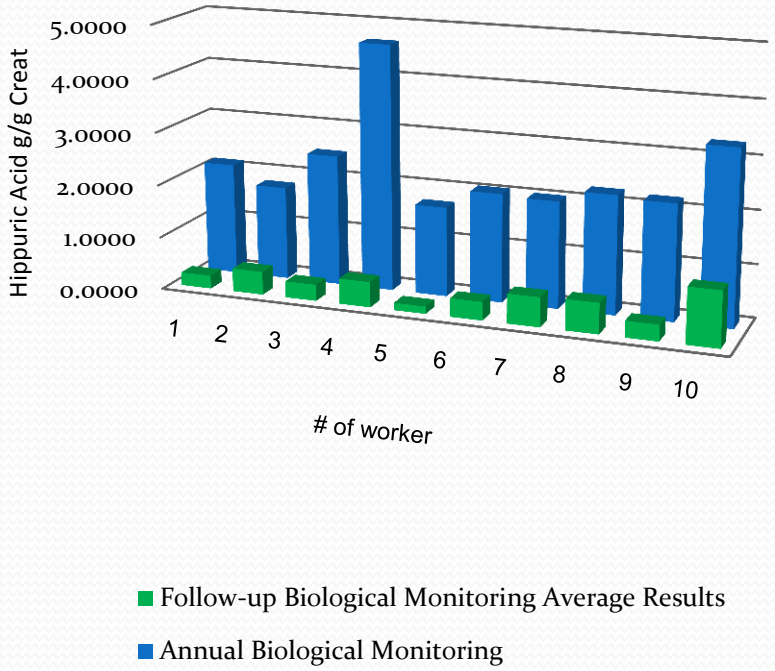


Follow-up Biomonitoring Results of Workers Found Overexposed

Follow-up Biological Monitoring of Benzene



Follow-up Biological Monitoring of Toluene



Final Conclusions:

1. **We consider useful and suitable the proposed Model because allows us:**

   a) To identify True Positive: workers with exposure above the BEIs or Adopted Reference Values, overexposed.

   b) To identify False Positive: workers with nonoccupational exposure, with high concentrations prior to shift.

   c) To verify the effectiveness of the Industrial Hygiene measures through the Follow-up Biomonitoring.

2.- **There is a need to prove this Model with more specific and sensitive biomarkers of exposure.**

General Acknowledgments

- To the Organizers of the 30th INTERNATIONAL CONGRESS ON OCCUPATIONAL HEALTH.
- To PETROLEOS MEXICANOS (PEMEX).
- To the Vice Director of Health Services of PEMEX, Dr. Victor Manuel Vázquez Zárate.
- TO THE PETROCHEMICAL SUBSIDIARY ORGANISM OF PEMEX.
- TO THE REFINING SUBSIDIARY ORGANISM OF PEMEX.
- To the Vice Manager of Occupational Health Services of PEMEX, Dr. José Tudón Martinez.
- To Dr. Arnulfo Albores Medina of Center of Research and Advanced Studies (CINVESTAV), Mexico.
- To all the Occupational Health Workers and Industrial Hygienists who implement the Biomonitoring Programmes in PEMEX.
- To the Chemists, Technicians and Secretary of the Industrial Toxicology Laboratory of PEMEX.
- To my Wife and Daugthers for their valuable support.