Evaluation of mutagenic activity of external factors

Evaluación de la actividad mutagénica de factores externos

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Abstract

Petrochemical enterprises dominate the system of the economic potential of our country. These enterprises, according to Russian legislation, are classified as carcinogenic. The technological process of this industry has excellent potential for improvement, which is predominantly expressed in the areas of technological, sanitary, and technical labor protection. However, according to the technical regulations, it is challenging to achieve complete industrial safety, which forms the list of problems of carcinogenic industrial facilities. Hence, the main objective of the present study is to evaluate the mutagenic activity of external factors. To accomplish that aim, experimental research is conducted. The results of this research can serve as a starting point in developing preventive measures to reduce the level of mutagenic hazard at carcinogenic enterprises.

Keywords: mutagenic hazard, genotoxicity test, working area, petrochemical enterprise, chromosomal and chromatid aberrations

Resumen

Las empresas petroquímicas dominan el sistema del potencial económico de nuestro país. Estas empresas, según la legislación rusa, están clasificadas como cancerígenas. El proceso tecnológico de esta industria tiene un excelente potencial de mejora, que se expresa predominantemente en las áreas de protección tecnológica, sanitaria y técnica laboral. Sin embargo, de acuerdo con los reglamentos técnicos, es un desafío lograr una seguridad industrial completa, que forma parte de la lista de problemas de las instalaciones industriales cancerígenas. Por lo tanto, el objetivo principal del presente estudio es evaluar la actividad mutagénica de factores externos. Para lograr ese objetivo, se lleva a cabo una investigación experimental. Los resultados de esta investigación pueden servir como punto de partida en el desarrollo de medidas preventivas para reducir el nivel de riesgo mutagénico en empresas cancerígenas. Palabras clave: riesgo mutagénico, prueba de genotoxicidad, área de trabajo, empresa petroquímica, aberraciones cromosómicas y cromátidas.

Introduction

Currently, almost all carcinogenic substances are proven to be mutagens[1-3]. However, the mechanism of development of tumor states as a result of mutagenic effects follows different scenarios[4-6].

Scientific cooperation of geneticists, oncologists, and ecologists is necessary and can reveal additional mechanisms and patterns in studying this phenomenon[7,8].

The cooperation is also interesting in matters of antimutagenesis, anticarcinogenesis. The mechanism of direct and long-term effects of exposure to harmful substances of this direction is described[9-11].

The issue is about the formation of gene mutations and chromosomal aberrations[12-14].

There is evidence that newly emerging mutations cause at least 50% of spontaneous abortions; at least 25% of congenital malformations result from new mutations of all types; 15% of perinatal mortality is the result of the effect of the mutation process[15,16].

Therefore, this study primarily intends to assess the mutagenic activity of external factors.

Methods

To meet the aim of the study, experimental research was carried out in several stages:

- air sampling from working areas (186 samples), the initial matrix was 1090 x 14;
- experiments for a short-term test for evaluating the mutagenic activity of the samples taken. Method: "Short-term test for chromosomal and chromatid aberrations in the experiment with Crepis capillaris by bioindication of the mutagenic background of the external environment No. 05-485, 2003"[2-5];
- counting of chromosomal and chromatid aberrations[17,18];
- determination of the type of violations (multiple deletions, translocations, separation of small and large chromosome arms, acentric deletion, etc.)[19,20];
- identification of points with the highest level of mutagenic activity[21,22];
- qualitative and quantitative analysis of the air environment[23,24];
- the study of causal relationships in the "Characteristics of substances - the level of induced mutagenesis"[25-27]
- statistical processing of the material with the use of parametric and non-parametric statistical methods[11,12].

Results and Discussion

For an objective comparative scientific analysis, control and experimental groups have been formed. The control conditions were zones free of industrial air pollution. The working zones of a petrochemical enterprise's permanent workplaces were considered experimental conditions.

Characteristics of the mutagenic background of the control area:

- Number of metaphases - 1060
- Number of aberrations - 8
- Type of aberrations - deletions

Characteristics of the mutagenic background of working areas:

- Plate shop, job - vulcanizer; number of metaphases - 1073; number of aberrations - 20; type of aberration - deletion, multiple lesions; reliability criterion (in comparison with control) - 1.09; level of significance (in comparison with control) - ($P < 0.05$);
- Continuous vulcanization section, job - extrusion machine operator; number of metaphases - 1027; number of aberrations - 23; type of aberrations - deletions, isochromatid deletions; reliability criterion (in comparison with control) - 1.54; level of significance (in comparison with control) - ($P < 0.05$);
- Molding section, job - molding vulcanizer; number of metaphases - 2037; number of aberrations - 22; type of aberration - deletion, multiple deletions; reliability criterion (in comparison with control) - 1.89; level of significance (in comparison with control) - ($P < 0.05$);
- Lead press section, job - lead press operator; number of metaphases - 1118; number of aberrations - 28; type of aberration - deletion, dicentric, acentric ring with microfragments; reliability criterion (in comparison with control) - 2.1; level of significance (in comparison with control) - ($P < 0.05$);
- Preparatory production, job - roller dyer; number of metaphases - 1014; number of aberrations - 21; type of aberration - deletion, multiple deletions; reliability

criterion (in comparison with control) - 1.92; level of significance (in comparison with control) - (P <0.05);

- Calender line, job - callender machine operator; number of metaphases - 1082; number of aberrations - 24; type of aberration - deletion, multiple deletions, dicentric; reliability criterion (in comparison with control) - 1,57; level of significance (in comparison with control) - (P <0.05);

- mechanical rubber mixture feed section, job - roller; number of metaphases - 1074; number of aberrations - 26; type of aberration - deletion, multiple deletions, translocations; reliability criterion (in comparison with control) - 2.63; level of significance (in comparison with control) - (P <0.05);

- Non-molded production section, job - machine operator; number of metaphases - 1074; number of aberrations - 26; type of aberration - deletion, multiple deletions, translocations; reliability criterion (in comparison with control) - 2.63; level of significance (in comparison with control) - (P <0.05);

- mechanical rubber mixture feed section, job - roller; number of metaphases - 1072; number of aberrations - 23; type of aberration - deletion, multiple deletions, isochromatid deletions; reliability criterion (in comparison with control) - 2.21; level of significance (in comparison with control) - (P <0.05);

- Lead press section, job - machine operator; number of metaphases - 1087; number of aberrations - 27; type of aberration - deletion, isochromatid deletions, acentric ring with microfragments; reliability criterion (in comparison with control) - 1.95; level of significance (in comparison with control) - (P <0.05);

- Technical plate section, job - roller; number of metaphases - 1082; number of aberrations - 32; type of aberration - deletion, multiple deletions, translocations; reliability criterion (in comparison with control) - 2.08; level of significance (in comparison with control) - (P <0.05);

In parallel with the experiment and study of the air in the working areas with the use of "Short-term test for chromosomal and chromatid aberrations in the experiment with Crepis capillaris by bioindication of the mutagenic background of the external environment" a qualitative and quantitative chemical analysis of air was conducted. Our study identified a set of substances released into the air of working zones, such as vapors of carbon dioxide, gasoline, hydrocarbons, ethyl acetate, chromium, benzopyrene. The analysis found that the highest levels (statistically significant) of mutagenic activity are characteristic of the following areas: technical plates, continuous vulcanization, brake, mechanical rubber mixture feed, non-molded production, calendar line, preparatory production, press-leaded, molding equipment. Among the jobs that involve contact with conditions of high mutagenic activity, the following are noted: a roller operator, a calendar operator, a roller-dyer, and a lead press operator.

Overall, based on these results, it can be stated that:

- application of a short-term test for chromosomal and chromatid aberrations in the experiment with Crepis capillaris by bioindication of the mutagenic background under the influence of industrial factors of ecology objectively evaluates the severity of induced mutagenesis;

- the priority pollutants of a petrochemical industrial facility are vapors of carbon dioxide, gasoline, hydrocarbons, ethyl acetate, chromium, and its compounds, benzopyrene;

- reliably high levels by types of aberration were noted for multiple deletions, isochromatic deletions, displacement of the chromosome bridge to the periphery, forming acentric chromosomes with micro fragments;

- production sections with a high level of mutagenic activity were identified - sections of technical plates, continuous vulcanization, brake, mechanical rubber mixture feed, non-molded production, calendar line, preparatory production, press-lead plating, and molding;

- jobs that involve contact with high mutagenic activity have been identified - a roller operator, a calendar operator, a roller-dyer, and a lead press operator.

Conclusions

Our study made it possible to assess the level of mutagenic activity that forms at an industrial facility with a petrochemical profile and identify priority pollutants areas with a reliably high level of genotoxicity and describe the range of occupations that are in the group of high reproductive risk. At the same time, the results show a range of areas in the study of this problem. Prospective studies include the development and construction of models based on methods of mathematical modeling, which allow identifying and assessing risk factors in modern petrochemical industrial facilities [21, 22, 23].

The ability to predict and manage risk factors is the basis for developing management mechanisms to minimize and eliminate occupational mutagenic hazards and prevent occupational and occupationally-related pathology.

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